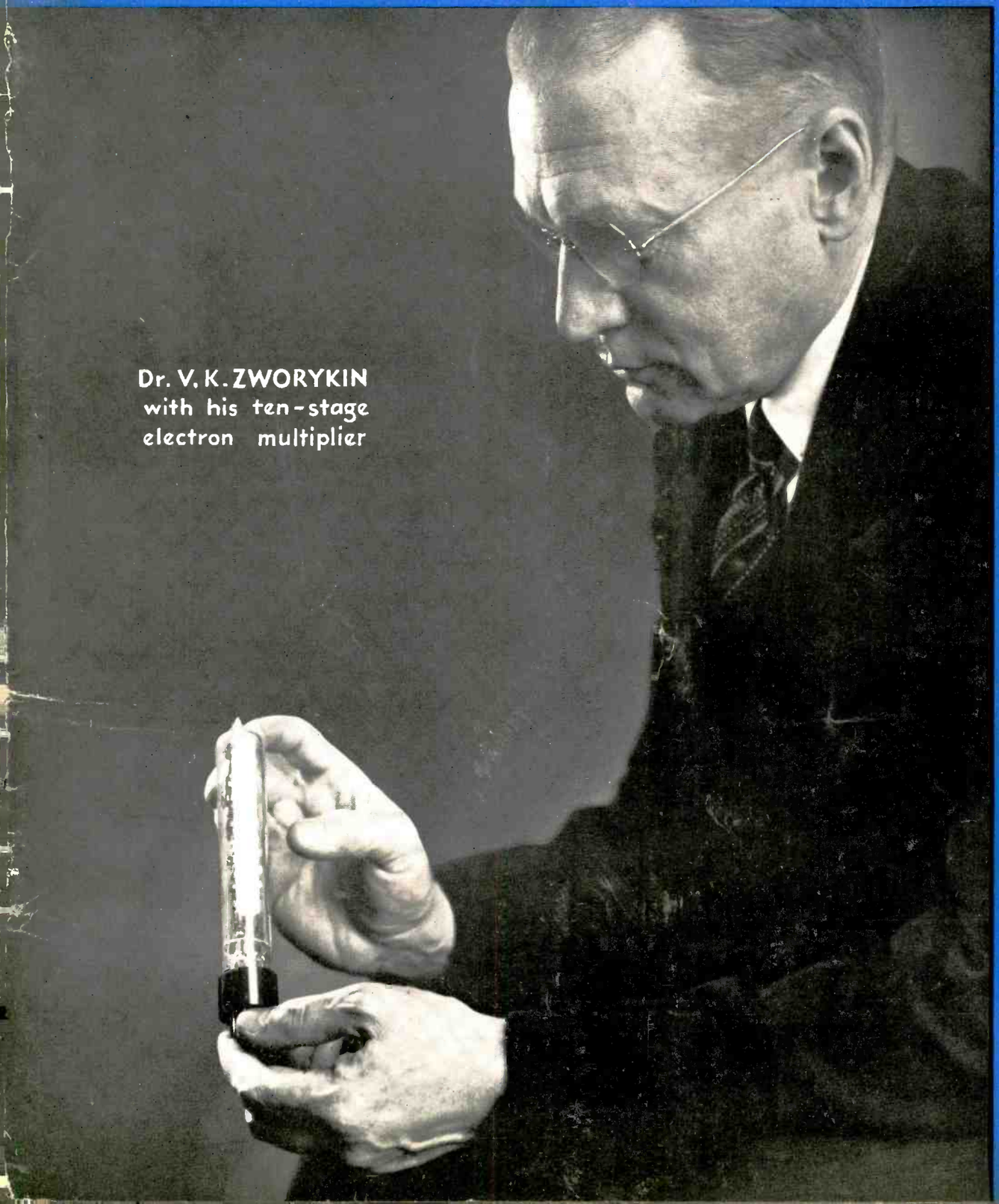
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



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NOVEMBER
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ELECTRONICS

radio, communication and industrial applications of electron tubes . . . design, engineering, manufacture

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CONTENTS

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DEPARTMENTS

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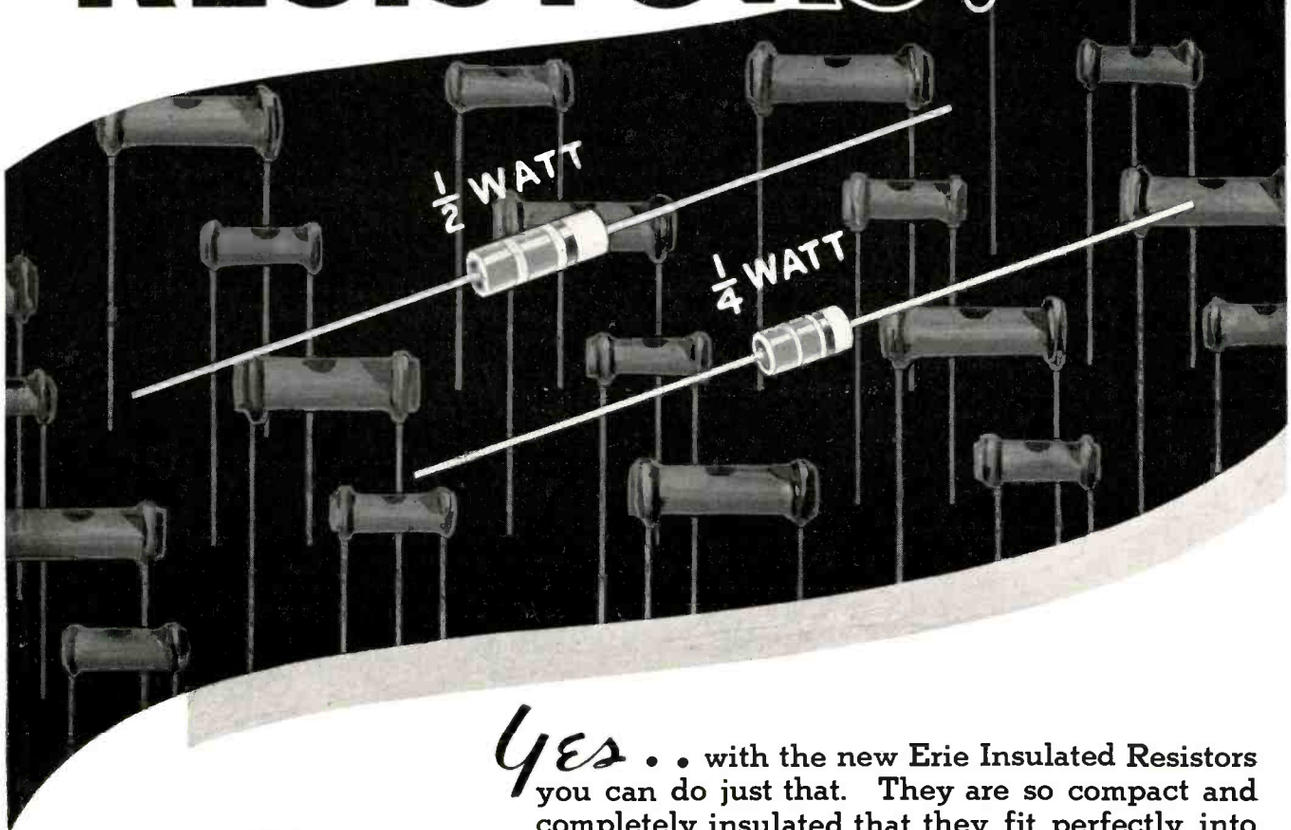

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ELECTRONICS

NOVEMBER
1935

KEITH HENNEY
Editor

Crosstalk

▶ **ZWORYKIN-ARMSTRONG** . . . Two most important I.R.E. papers are reviewed in this issue of *Electronics*. On October 23, Dr. V. K. Zworykin of RCA Victor's Electronics Research Laboratory disclosed his recent work on secondary emission electron multiplier tubes; tubes which will deliver a voltage gain well over a million, per tube, with a signal-to-noise ratio better by 100 times than present systems. These new tubes seem to be potential rivals of the thermionic amplifier, oscillator, detector.

On November 6, E. H. Armstrong of Columbia University reported on his frequency modulation system which marks still another step toward conquering the noise which now distorts sight and sound programs. On the very short waves Armstrong has demonstrated that new possibilities lie in this form of modulation, often suggested and as often discarded.

Both of these important developments will be described completely in the Proceedings of the Institute of Radio Engineers.

▶ **TOWN HALL**, no less . . . Saturday afternoon, October 19, Town Hall, New York, Leroy Anspach, control operator at WCAU appeared in a piano recital and according to I. S. of the New York Times, "the large audience gave warm applause." Mr. Anspach handles the Philadelphia orchestra broadcasts, has appeared with that organization in Robin Hood Dell and at the Lewisohn Stadium.

▶ **NIGHT WORK** . . . Never have the radio components manufacturers seemed so busy. On a recent trip around New York we find plants running in two and three shifts trying to keep up with the mounting production of new radio receivers. It is most encouraging. All things point to a year passing all previous twelve-month periods.

At the moment, chief items of scarcity seem to be coils and cabinets. Metal tubes are rolling out to the tune of 50,000 per day (our guess) and most of them stay out. A few manufacturers, however, swear they will not use them, one in Chicago says, "as don't relish poison won't use metal tubes this year."

▶ **AMONG US ANTENNA EXPERTS** . . . Mr. Robert S. Kruse of Guilford, Connecticut, states "In Fig. 1 of the very good Dietsch paper on antenna termination (page 15, Sept. issue) the upper or parallel-wire curve is not strictly right. The 'natural' tendency of this curve is to become asymptotic, eventually descending to zero at the remote point where $S = 0$ which is also $S/d = 0$. However that course is abruptly terminated when a short-circuit happens at the moment of tangential contact, which takes place at $S/d = 1$. Therefore the curve should continue smoothly along its eventually-asymptotic course until at $S/d = 1$ it suddenly falls down a well to zero. In other words there isn't a downward curve, but an abrupt kink."

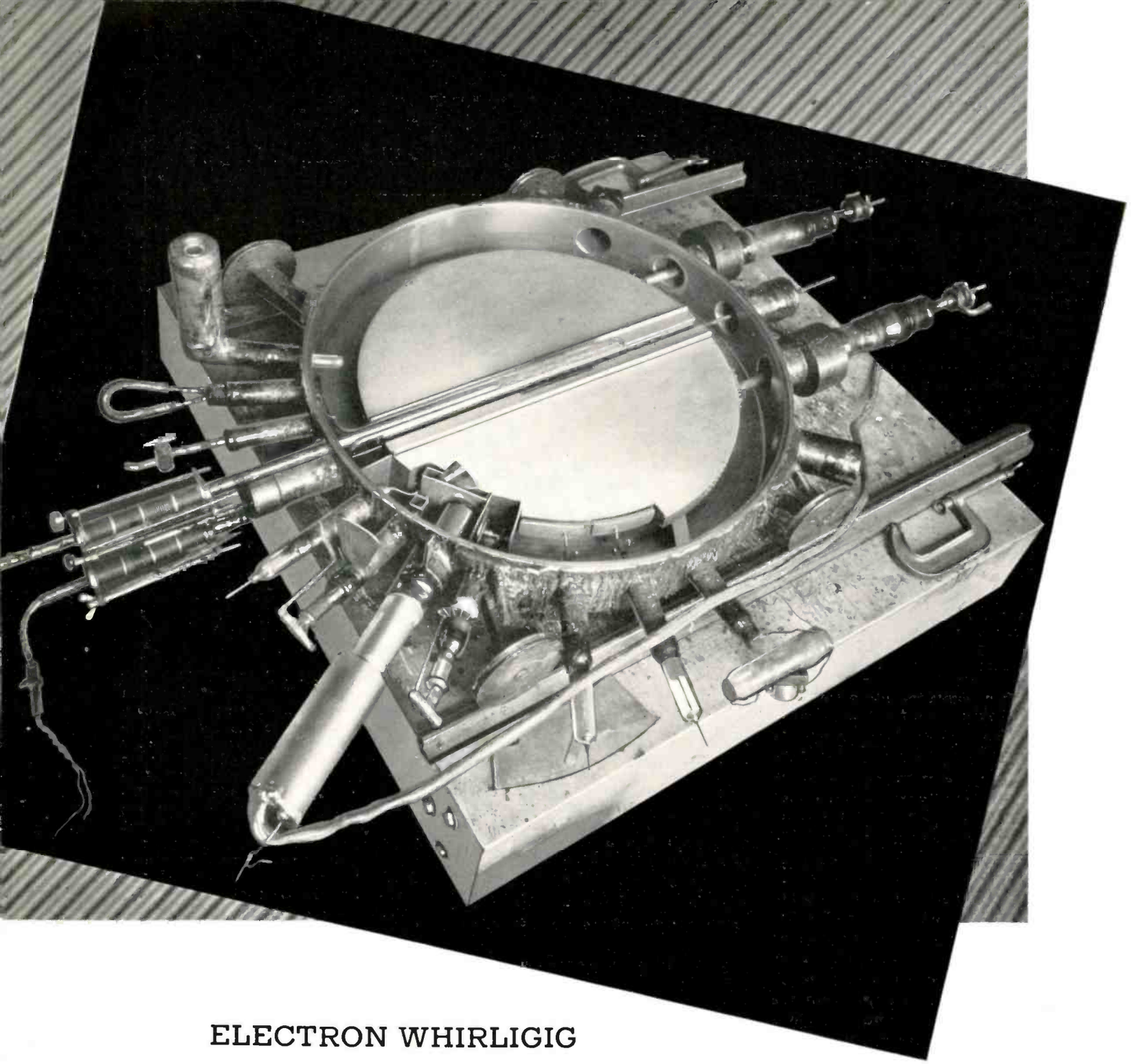
▶ **OFF AGAIN**, on again . . . An Australian manufacturer of radio sets in this country after touring Europe wavers between metal tubes and the better known glass tubes. On three successive days he cabled his tube supplier in England, "rush metal tube work. Must have them." "Disregard cable of yesterday. Metal tubes a flop." "Metal tubes ok. When can you deliver?"

▶ **SCANDALOUS** . . . Elaborate Photophone sound re-inforcement apparatus will provide natural sound for every seat when the newest edition of George White's Scandals opens the middle of November. RCA Engineers are installing special equipment of the portable type. Al Lee, manager of the Scandals, believes that sound re-inforcement of the high fidelity type has become an indispensable adjunct to stage shows.

▶ **GAMBLE** . . . Research, according to Dr. C. E. K. Mees of Eastman Kodak, is a gamble. It cannot be conducted according to the rules of efficiency engineering. Speaking to fifty industrial executives and bankers on tour, he stated that "research must be lavish of ideas, money and time. The best advice that I can give is don't quit easily, don't trust anybody's judgment but your own; especially don't take any advice from any commercial person or financial expert, and, finally, if you really don't know what to do, match for it." Furthermore Dr. Mees said, "The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department.

"After that you leave the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finally there is the committee of company vice presidents, which is wrong all the time."

▶ **OBIT** . . . Alfred H. Grebe, prominent radio manufacturer and engineer, died suddenly October 24, at the age of 40. One of the pioneers in the radio set manufacturing field, his first catalog of radio apparatus was put out when he was 19 years old. In the early days of broadcasting his signals were heard over the world from Richmond Hill, the site of his manufacturing plant, from which many thousands of receivers were shipped, many of them still giving good service. Mr. Grebe had recently reorganized his company, and was actively preparing new products for the radio market.



ELECTRON WHIRLIGIG

In this acceleration chamber, deuterons attain the enormous speeds necessary for penetration of atomic nuclei. An oscillator endows each particle with increasing energy as it whirls under the influence of an intense magnetic field

Radioactivity by Bombardment

A high frequency oscillator is used in a new bombardment technique whereby ordinary elements are converted into radioactive ones, thus producing inexpensive radium substitutes suitable for medical and laboratory use. The theory and practice of the process

By JOHN J. LIVINGOOD, Ph.D.
Radiation Laboratory
Department of Physics
University of California

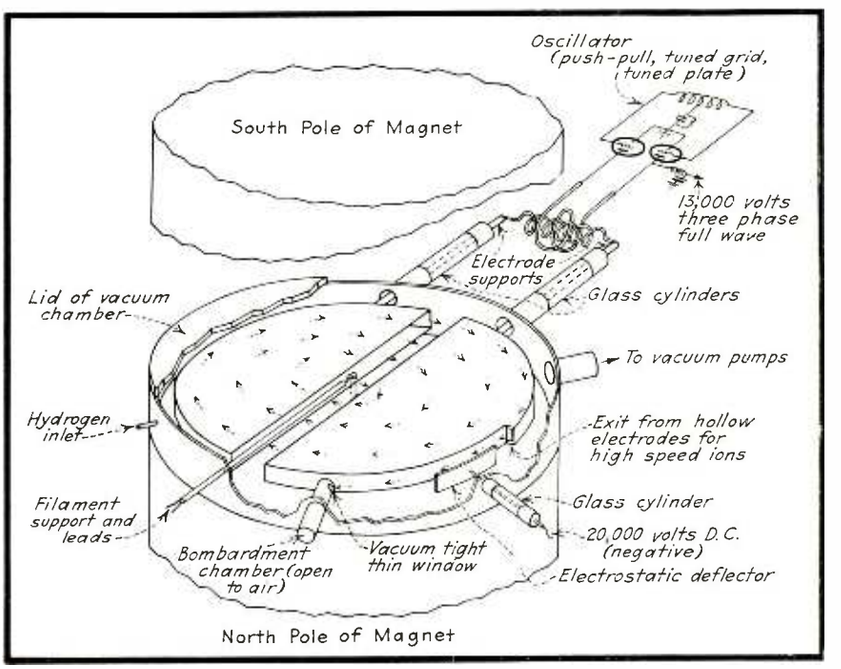
THE first successful transmutation of the chemical elements was performed by Rutherford[1] in 1919, not by chemical means, but by the physical process of driving one type of atom into another. It is the nucleus — the innermost part — which ultimately determines the chemical properties of an atom, and as all nuclei are positively charged, enormous repelling forces are exerted when two nuclei are brought into close proximity. Hence if one is to penetrate into another, it must be endowed with sufficient kinetic energy to overcome the repulsion. Rutherford used as projectiles the most energetic bodies then known, the helium nuclei (so-called alpha particles) spontaneously emitted by radium, and allowed them to fall on nitrogen. Occasionally a direct hit was made and an alpha particle penetrated within a nitrogen nucleus; the over-stuffed body immediately burst into two parts, one a hydrogen nucleus and the other constituting a nucleus of oxygen.

The study of such transmutations by alpha particle bombardment is seriously handicapped by the scarcity and high cost of radium; with the largest available amounts, the alpha particles emitted every second are relatively so few that the labor of observing the occasional disintegrations is extremely tedious. Consequently much effort has been expended in the development of apparatus to accelerate by electrical means large numbers of charged particles to be used as projectiles, such as protons or deuterons (the nuclei of ordinary and of "heavy" hydrogen) for theory indicated they might be more effective as disintegrators than the heavier alpha particle.

Such an acceleration may be accomplished by establishing a large difference of potential between two electrodes at the ends of an evacuated tube, introducing the positively charged particle at the anode and letting it be drawn to the cathode by the electrostatic force. The kinetic energy thus generated, when expressed in joules, is equal to the product of the charge of the particle, in coulombs, and the potential drop, in volts.[2] Considerable success has rewarded these efforts and several laboratories in different countries are now carrying on nuclear disintegration experiments with proton or deuteron currents up to 100 microamperes, at potentials from 600 to 1,200 kilovolts. The potential is supplied by transformers, with[3] or without[4] kenotron rectification, or by electrostatic generators[5] of the Van de Graaff type[6]. The installations are bulky, however, since large clearances must be allowed to prevent external flash-over, and considerable trouble has been experienced by puncture of the glass or porcelain tubes by high speed electrons.

It was in an endeavor to avoid these inherent disadvantages of high voltage equipment that Lawrence and Livingston at the University of California developed a method for producing energetic particles without the use of high voltage[7]. In principle, the scheme is to allow the particle to pass through a series of hollow electrodes, a relatively low potential source being successively connected at the proper instants to those two electrodes between which the particle happens to be. The final energy of the particle is therefore equal to that obtained from a single fall across the potential of the source multiplied by the number of times this has been applied. The practical realization of this is as follows.

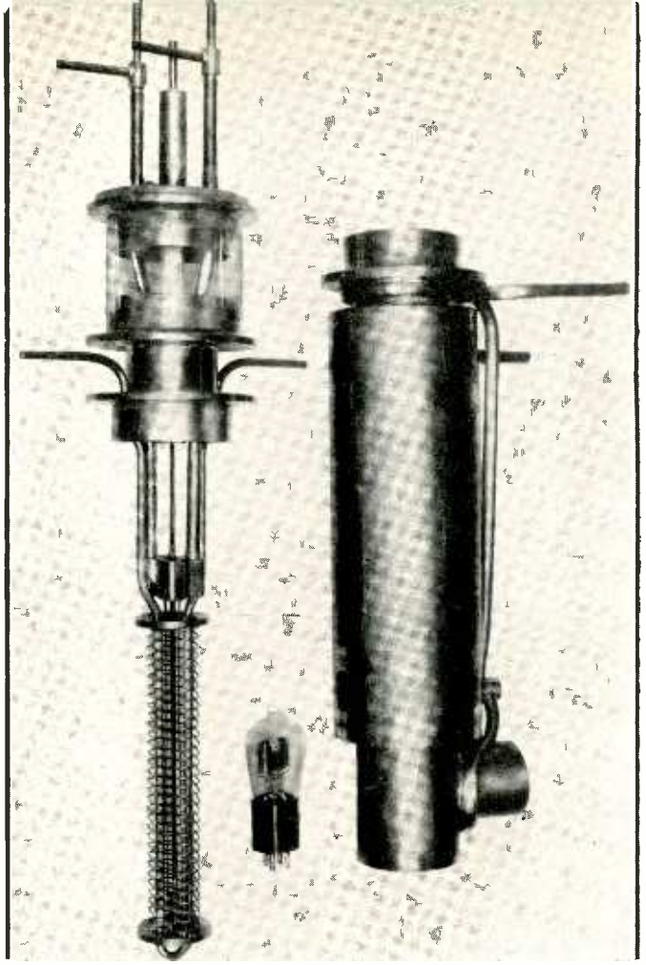
A cut-away view of the acceleration chamber showing the relation of the magnetic field, acceleration electrodes, deuteron paths, and the bombarded atoms



A large electromagnet produces a uniform field across a flat evacuated chamber between its pole faces. Inside this chamber and insulated from it are two semi-circular hollow electrodes, shaped very much like the two halves of a cylindrical pill box that has been cut in two along a diameter. These two electrodes are connected to a high frequency oscillator so that, like the plates of a condenser, they become charged alternately positively and negatively several kilovolts with respect to ground. If a positively charged particle is produced near the center of this system, it will be drawn into that electrode which at the moment is negative. Once inside, it is free of all electric forces but is acted on by the magnetic field, which bends the path of the particle into the arc of a circle.

After describing a semi-circle, the particle comes back to the gap between the electrodes; if the frequency of the oscillator has been properly chosen, the potentials of the electrodes have now become reversed, so that the particle receives a second acceleration and enters the other electrode. It is now going faster and therefore describes a larger semi-circle, coming back to the gap just when the potentials have again changed and so it undergoes a third increment of energy. The particle thus traverses a path that spirals outward from the center, receiving constant additions to its kinetic energy every time it crosses the diameter of the chamber, finally passing through a slit in the outer edge of one electrode with an energy equal to that gained in travelling from one electrode to the other multiplied by the number of such crossings.

This method of successive, properly synchronized impulses is possible because the time required for the particle to describe a semi-circle is not dependent on the radius of curvature; particles near the center traverse a small semi-circle at low speed, while those near the periphery travel a longer distance but at a correspondingly greater speed. Therefore one single and constant frequency of the oscillator is correct for all successive steps in the acceleration. This may be shown very simply. The time required to travel, at velocity v, a semi-circular path of radius r is



Right, a specially designed demountable oscillator tube of 30 kw. power, used to feed high frequency a-c to the accelerating electrodes

Extreme right, a general view of the bombardment apparatus, showing the huge magnet which produces the field necessary in the atom - disintegrating process. The acceleration chamber (see Frontispiece) is the center of the picture, midway between the poles of the magnet

$$(1) \qquad t = \frac{\pi r}{v}$$

The centrifugal force due to the curved path is Mv^2/r, where M is the mass of the particle. This is equal to the centripetal force Hev due to the magnetic field H, where e is the charge of the particle. Hence we have

$$(2) \qquad \frac{Mv^2}{r} = Hev$$

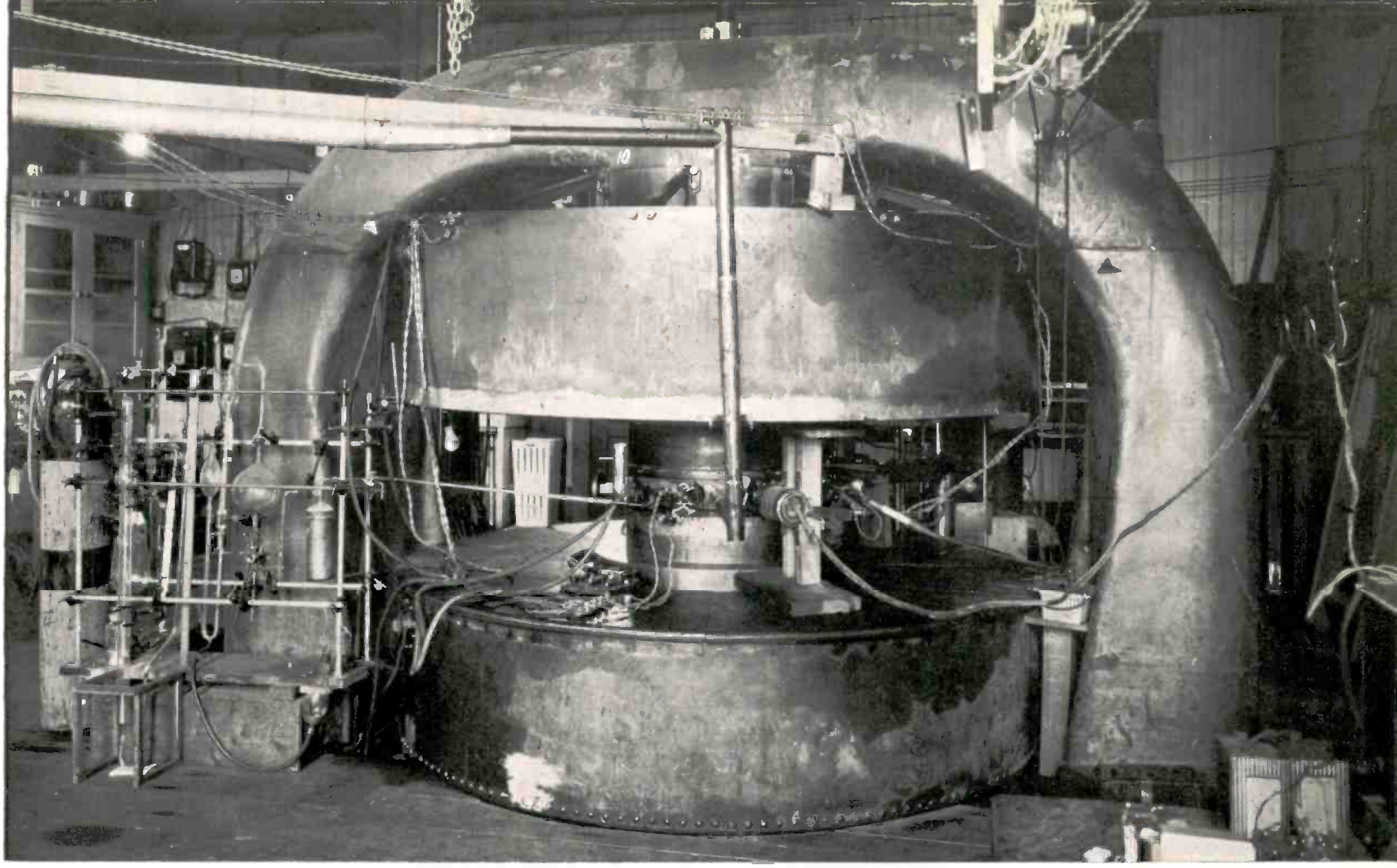
so that on solving for v and substituting it in the equation for t we find that

$$(3) \qquad t = \frac{\pi M}{He}$$

This is constant for a given type of particle and a given H, so that, as was to be proved, t is independent of the radius of the path. The proper wavelength for synchronization is found by setting t equal to one half the period of oscillation.

As may be seen from equation (2), the velocity and therefore the kinetic energy of the particle depend on both the magnetic field and on the radius of curvature. The highest energy that can be attained is hence limited by the size and strength of the magnet available. The first apparatus to be built had pole faces 5 inches in diameter and demonstrated the practicability of the method; the second was 11 inches across and delivered proton currents of 10^{-9} ampere at 1,200,000 electron-volts. The third model was designed around a huge 75 ton magnet originally built for a Poulsen arc and, as used at present, yields 10 microamperes of deuterons at 4,000,000 electron-volts.

As rebuilt, the magnet has pole faces 28 inches in diameter (capable of extension to 45 inches) and develops 16,000 gauss across a 6 inch gap with an exciting current of 65 amperes. The copper sheet electrodes, 11 inches in radius and 2 inches high, are supported, water-cooled and connected to the oscillator by pipes passing out of the wall of the vacuum chamber through glass insulating cylinders. The chamber is evacuated by an Apiezon oil diffusion pump, and an adjustable valve admits "heavy" hydrogen to the optimum pressure to produce the greatest final current without causing an electrical glow discharge in the tank. The "heavy" hydrogen ions, or deuterons, are formed by electron bombardment supplied by two hot filaments mounted above and below the gap between the electrodes, near the center of the chamber; the filaments are maintained a thousand



volts negative with respect to the vacuum tank, so that electron currents of 100 milliamperes pass up and down, producing a region of intense ionization. The high speed deuterons, on reaching the walls of one of the electrodes, pass out of it through a slit and are increased slightly in radius of curvature by an electrostatic deflecting field. This enables them to clear the wall of the electrode and to pass through a very thin but vacuum tight metal window soldered to a re-entrant cylinder let into the side of the tank. This is the bombardment chamber, outside the vacuum, into which various materials may be placed for exposure to the stream of high speed ions.

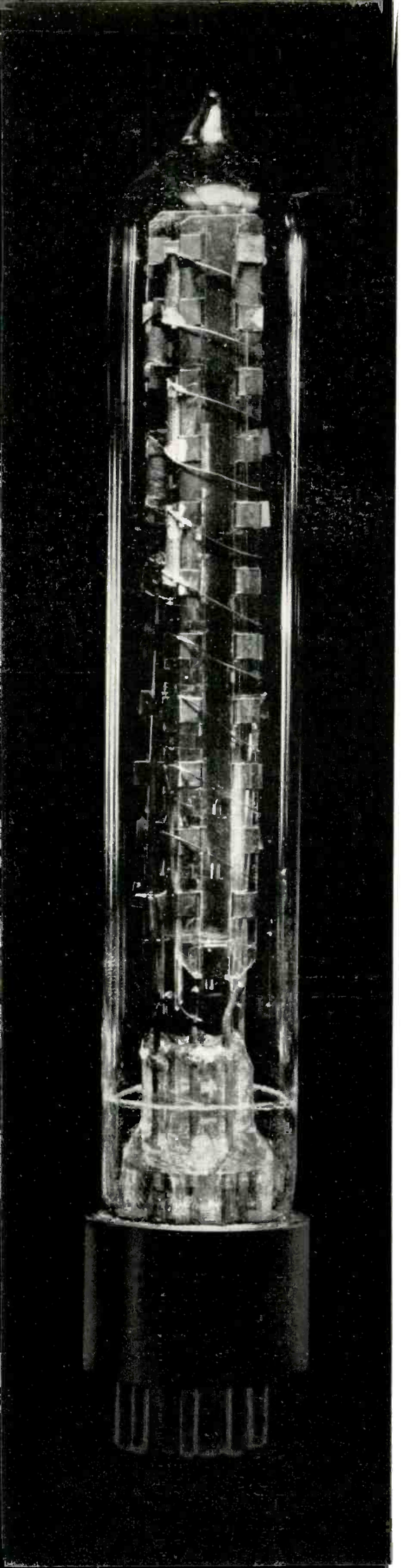
The oscillator circuit is a simple push-pull, tuned grid, tuned plate hook-up, running at about 25 meters wavelength. The anodes are supplied with three phase, full wave rectified current at 13,000 volts, through the use of six hot cathode mercury vapor tubes. The demountable oscillator tubes, of about 30 kilowatts each, were designed and built in the laboratory.[8] The water-cooled anodes form part of the vacuum jacket, the remainder being furnished by the two glass cylinders which insulate the grid mounting from the anode and the filament structure from the grid. As the glass-to-metal joints are made with sealing wax, bake-out is impossible and the tubes are continuously evacuated by Apiezon oil diffusion pumps.

Although the magnitude of current produced by this apparatus, thus far in its development, is somewhat less than that given by those machines employing single step acceleration by high voltage, nevertheless the very superior final energy given the projectile more than makes up for this deficiency. This is for two reasons; first, the particles having greater energy are able to penetrate further into the target and hence pass through more atoms, with a correspondingly greater chance of making a direct hit on a nucleus; second, the probability of a disintegration occurring, once a collision has been made, rises rapidly as the energy of the particle is increased.

Not only is the machine particularly useful in the study of transmutations produced by high speed deuterons, but it is also, at present, the most powerful source of neutrons in existence. These peculiar bodies, discovered[9] only three years ago, have the mass of a proton but no electric charge at all, and consequently are not repelled by any nucleus they strike. They therefore are extremely efficient projectiles for disintegration experiments. The simplest neutron source is a mixture of beryllium and radium; alpha particles shot off from the latter disintegrate the beryllium, causing the formation of carbon and neutrons. Alternatively, one may bombard beryllium with deuterons and obtain boron and neutrons. This reaction is much more efficient than the former, and in addition, the number of deuterons supplied by the machine every second is so great that the neutron yield is as large as that which would be given by a mixture of beryllium and 100 kilograms of radium. It is therefore not surprising that seven machines of this type are now in process of construction in laboratories both in America and abroad.

Practically every one of the eighty-nine known chemical elements has been disintegrated within the past few years by bombardment with either protons, deuterons, neutrons or alpha particles. In general, the process consists in the capture of the projectile by the struck nucleus, followed instantaneously by the bursting into two parts of the temporary body thus formed. One of these pieces is either a proton, an alpha

[Continued on page 60]



Secondary Emission

New electron multipliers that will detect, modulate, oscillate and amplify by the successive use of secondary emission with improved signal-to-noise ratio

NEW uses for the phenomenon of secondary emission were announced by Dr. V. K. Zworykin, D. A. Morton, and L. Malter at the October meeting of the New York section of the Institute of Radio Engineers. The new developments take the form of unusual vacuum tubes which make use of the fact that a single electron impinging on a specially prepared surface (or "target") can liberate as many as ten secondary electrons, thereby producing a current amplification of 10 to 1. By arranging several cascaded "stages" of such electron multiplication, tubes of extremely high gain have been produced.

In the design of conventional thermionic tubes, secondary emission from the grid or plate of the tube has been a serious handicap inasmuch as it increases the space charge and decreases the relative control of the grid on the space current. But secondary emission has been put to practical use as early as 1919. The first practical use of the effect was made by Dr. Hull, in the dynatron. The idea of amplifying a small electron current by means of secondary emission has been investigated by Slepian, Jarvis and Blair, Iams, and Farnsworth. An electron multiplier developed by the last mentioned, P. T. Farnsworth, was described in *Electronics*, August, 1934, pages 242 and 243.

The new tubes, which were developed in the Electronics Research Laboratory of the RCA Manufacturing Company in Camden, require about the same amount of power for operation as do conventional tubes (about 17 watts per ampere of emission) but they are considerably superior from the standpoint of noise.

A ten-stage tube, enlarged by 1.5 times. The tube is actually somewhat longer than the 59

In the case of the multiplier photocell, the signal-to-noise ratio is approximately 60 to 100 times greater than that of the usual photocell and thermionic amplifier, under conditions of low light intensity. In addition to this improvement in signal-to-noise ratio, the new tubes have the advantage that they can produce enormous gains in a very compact space, often in fact incorporating ten stages of amplification within the same envelope, with resulting gains of several millions. In addition, the tubes may be made to perform the different functions of modulation, oscillation and amplification within the same envelope, using different sections of the same tube. Such multipurpose tubes, although now in the experimental stage, may possibly be used in radio circuits, and other applications for which more conventional thermionic tubes are now used.

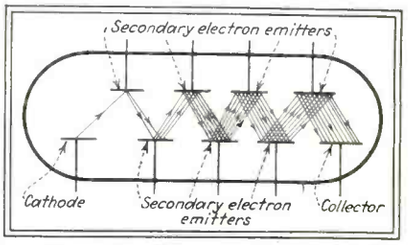


Fig. 1—Secondary emission tube—fundamental scheme

Multiplier Action

The general principle of the electron multiplier action is illustrated in Fig. 1. The cathode to the extreme left supplies an electron which is drawn in the direction of the arrow to the positively charged plate above it, which has a special surface having high secondary emission characteristics. There, the initial electron liberates two or more secondaries which in turn are drawn to the

Electron Multipliers

A report of the October 1935 I.R.E. meeting when Dr. V. K. Zworykin and his associates of the RCA Victor Research Laboratory demonstrated the new tubes

secondary electron emitter below where they produce still more secondaries. The process thus continues in criss-cross fashion until the original electron has been multiplied many times. The final collector at the extreme right of the tube collects the resulting amplified current and conducts it to an external circuit where it may be used. In electron multipliers of this type each secondary electron emitter must be maintained at a potential slightly more positive than the preceding one in order to attract the electrons. However, if this procedure is followed in the tube shown in Fig. 1 the maximum positive potential must be applied to the collector at the right of the tube, and as a result any electrons from the cathode are drawn directly to the collector without impinging on the intermediate emitters. This difficulty is overcome in the mechanical design of the new tubes as is described below.

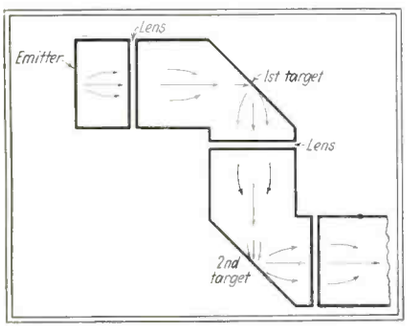
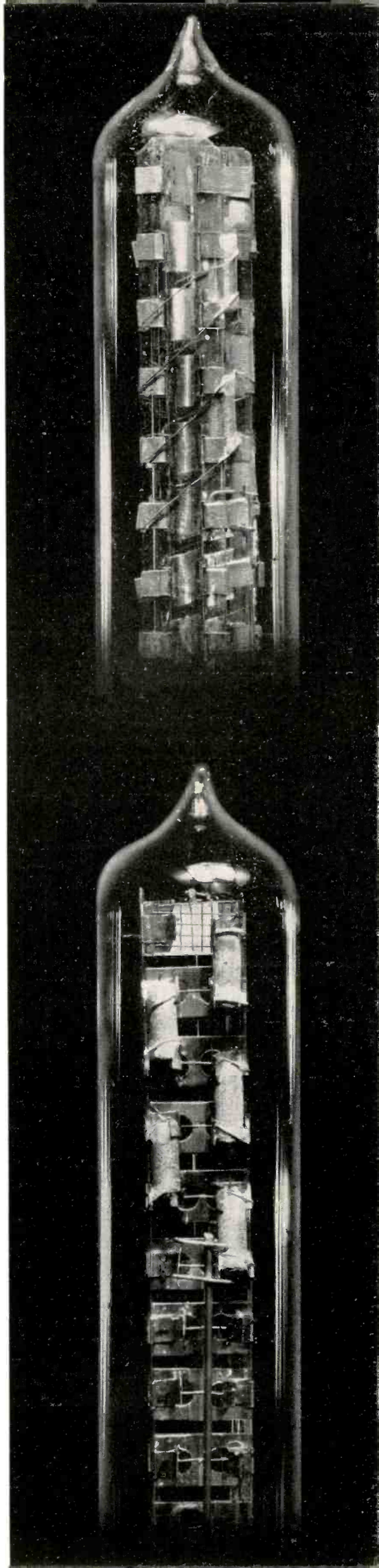


Fig. 2—A practical tube construction

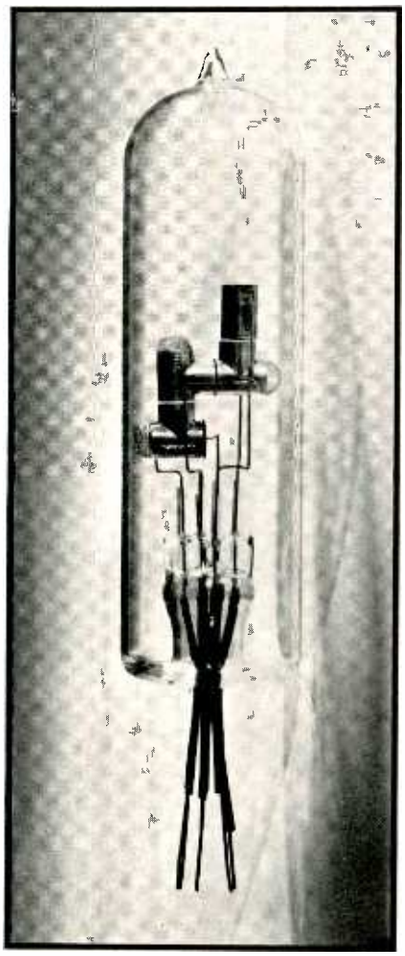
It will be seen from Fig. 1 that the requirements for high efficiency of electron multiplication are, first, a high ratio of secondary electrons emitted for each primary electron impinging on the surface; second, the collecting or drawing away of the secondary electrons from one target preparatory to focussing them on the next target; third, complete focussing of the electron beam (which would tend to diverge because of the similarity of charge) on each successive target.

The Emissive Surface

The search for a good emissive surface, that is one having a high ratio of secondary to primary electrons, has resulted in experiments with metallic elements having a low work function, and which therefore emit electrons easily. It has been found that simple metal surfaces are not as effective as composite surfaces. The most satisfactory surfaces have been those of oxidized silver, beryllium or zirconium with a caesium surface layer. The surface used in the new multiplier tubes is a caesium-caesium oxide-silver surface, produced by oxidizing a silver sheet having a matte surface, coating the silver oxide with caesium under vacuum, and then heating the surface so that the oxygen is transferred from the silver oxide to the caesium. This surface is very similar to the surface used in photoelectric cells, the only difference being that the photoelectric surface has slightly more caesium in its composition. Since the emissive surface is also a good photoelectric surface, it is not surprising that the electron multiplication principle has been applied first to the amplification of photoelectric currents. The number of secondary electrons emitted for each primary electron in such a surface depends upon the velocity with which the primary electron hits the surface. This velocity may be expressed in volts; for the surface described, the maximum secondary



Sections of the tube showing details of construction. The square plates (top) are emitters



The T-type multiplier, in a three stage form

emission of 7 to 10 secondaries per primary is reached at a velocity corresponding to approximately 450 volts.

Removing the secondary electrons and focusing them on the next target may be accomplished by the use of electrostatic or magnetic fields or by a combination of the two. The simplest arrangement is that using an electrostatic field. Tubes built on the electrostatic principle have taken two forms, the L-type and the T-type, shown in Figs. 2 and 3-A respectively. In both types an emitter (which may be a photoelectric surface or a thermionic surface) provides the electrons which are focussed by means of an electron lens on the first target. The electron lens consists of two cylinders separated by a short gap and connected to a constant difference of potential, which produces a radially symmetrical electrostatic field within the cylinder. This field focusses the beam of electrons, as shown by the arrows, on the center of the first target. At this target the secondary electrons are liberated and the current is amplified by the ratio of secondary emission to primary impact. Immediately a second electron lens focusses the resulting beam upon the second target where the process is repeated and a still greater number of secondary electrons proceeds towards the third target. By properly proportioning the voltages between the target, by the use of proper spacings between the cylinders and by the use of efficient surfaces, extremely great amplifications may be produced in this type of device. The electron stream changes direction by 90 degrees at each target, an arrangement which prevents the initially emitted electron from traveling directly to the final collector as would happen in the form shown in Fig. 1. This is the reason for the particular configuration of plates in the L- and T-types. With three targets and a secondary emission ratio of 8, the electron beam is multiplied by the cube of 8, that is, over 500 times. The type of tube shown in Fig. 2 (L-type) provides a sharp focus of the electrons, but the field in each target is weak and the tendency toward space charge limitation is correspondingly great. The T-type tube shown in Fig. 3-A has less sharp focus of the electron beam but a higher collecting field at each target. These tubes operate at 200 to 400 volts per stage, and provide an output current of the order of one milliampere.

Multiplier tubes using electrostatic fields, such as the L- and T-types just described, as well as those using both electrostatic and magnetic fields, have the possibility of producing enormously high gains as the number of stages is increased. For example, the magnetic type of photocell to be described can be made in as many stages as twelve, and with an overall gain of several million times. But gains of this order can be obtained with thermionic amplifiers, with approximately the same efficiency and with convenient, although considerably larger, equipment. For this reason the real advance of the electron multiplication principle over those provided by conventional thermionic amplifiers lies in the improvement of the signal-to-noise ratio. For this reason a considerable part of the investigation made by Dr. Zworykin and his associates has been devoted to a determination of the improvements provided in this respect.

When an ordinary photocell and thermionic amplifier are used the signal-to-noise ratio is determined by the thermal noise from the coupling impedance between the amplifier and the photo-cell. In the multiplier, however, no such coupling impedance is required and a considerably improved ratio is the result, particularly when a large frequency band width makes it necessary to use a low value of coupling impedance. In the multiplier, noise is produced by the statistical fluctua-

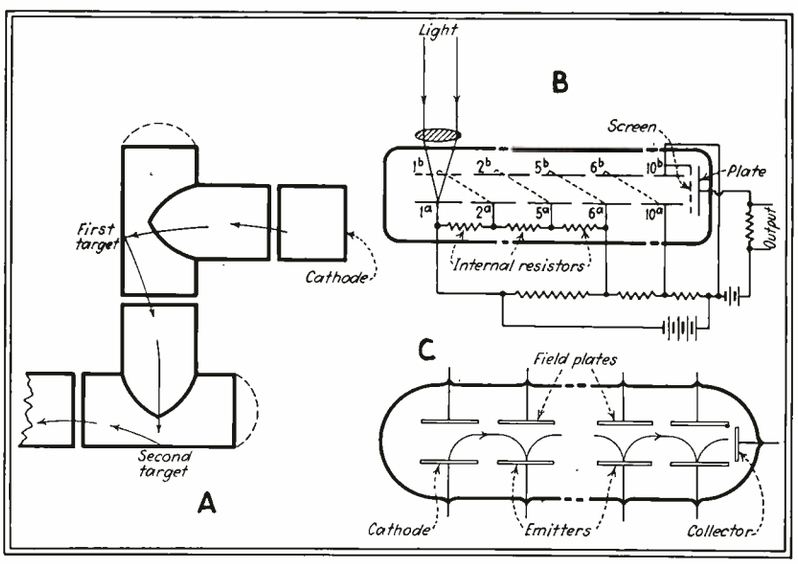


Fig. 3—(A) Diagram of the T-type multiplier. (B) Connection diagram of the magnetic multiplier photocell. (C) In the magnetic photocell the curved path of the electrons from emitter to emitter is caused by crossed elecrostatic and magnetic fields

tion of the useful electrons going through the tube. After multiplication at each target the noise in the beam is the original shot-effect noise in the initial beam multiplied by the amplification ratio and, in addition, the fluctuation noise of the secondary emission itself. The latter type of noise has not been thoroughly investigated. It appears, however, that the noise output of several different types of multipliers is proportional to the frequency band over which the measurements are made and also to the secondary electron current. The results of the experiments show definitely that a gain in signal-to-noise ratio of 60 to 100 times under ordinary conditions of operation may be obtained with the multiplier as compared with a thermionic amplifier, for values of light in which the photoelectric current is in the neighborhood of 10^{-9} to 10^{-11} amperes. This real improvement in the signal-to-noise ratio marks the multiplier as a distinct advance in amplification technique over all existing methods.

In addition to the high gain and high signal-to-noise ratio, the electron multipliers have an inherently flat frequency characteristic responding to very low frequency alternating current and to direct current equally as well as to frequencies of several hundred megacycles.

The application of the electron multiplication principle has found its highest form to date in the so-called magnetic secondary emission multiplier photocell, shown in the large photographs on pages 10 and 11. This device is a ten stage amplifier whose initial current is supplied by the photoelectric surface at the top of the element structure.

A schematic diagram of the ten-stage model is shown in Fig. 3B. The light focussed on electrode 1-a by means of a lens is transformed into an electron beam which is successively reflected from 1-a, 2-a, 3-a, etc. as shown in the diagram 3C. The field plates 1-b, 2-b, etc. are connected by internal connections (shown on dotted line) to the next following emitting plates. These field plates produce an electrostatic field which gives the secondary electrons their initial velocity as they leave the emitting plates. The curved path from emitter to emitter shown in Fig. 3C is produced by a magnetic field, supplied by a permanent magnet in such a way that the field direction is at right angles to the axis of the tube and normal to the electrostatic field between the upper and lower plates.

This crossed arrangement of electrostatic and magnetic fields has several advantages, in that it completely separates the primary and secondary electrons and does away with the space charge limitation of current. In practice, the combined electrostatic and magnetic fields act as a filter which separate the primary from the secondary electrons and focus all electrons from one stage on the following. The progressively increasing positive potential which must be applied to successive electrodes is obtained as shown in Fig. 3B from a bleeder resistor, which may be provided internally within the envelope of the tube.

The L-type multiplier, or "stove-pipe" photocell

The amplifying action can be used for oscillation by feed-back of energy or by the use of the negative resistance characteristics of the device. All of the common functions now associated with multi-element thermionic tubes can be performed by the electron multiplier.

Electron Multiplier Patents

The following is a partial list of patents issued on devices making use of secondary electron emission, either as a generator of negative resistance, or for its amplifying action. The list has been compiled by Mr. Norman L. Haight.

United States Patents

1,385,873, July 26, 1921; to A. W. Hull (G. E. Company) Electron Discharge Device. (Filed, 1916)

1,387,984, Aug. 16, 1921; to A. W. Hull (G. E. Company) Negative Resistance. (Filed, 1921)

1,419,547, June 13, 1922; to C. D. Ehret. Multiplier Action. (Filed, 1918)

1,450,265, April 3, 1923; J. Slepian (Westinghouse E. and M. Company) Hot Cathode Tube. (Filed, 1919)

1,559,460, Oct. 27, 1925; S. Ruben. Electron Tube. (Filed, 1920)

1,740,252, Dec. 17, 1929; to I. Langmuir (G. E. Company). (Filed, 1923)

1,748,386, Feb. 25, 1930; to S. Loewe (RCA). (Filed, 1925)

1,809,676, June 9, 1931; to C. A. Culver (Wired Radio, Inc.). (Filed, 1929)

1,941,344, Dec. 29, 1933; to P. T. Farnsworth. Dissector Target. (Filed, 1930)

1,903,569, April 11, 1933; to Jarvis & Blair. (Filed, 1926)

1,969,399, Aug. 7, 1934; to P. T. Farnsworth. Hot Cathode Electron Multiplier. (Filed, 1930)

1,970,036, Aug. 14, 1934; to P. T. Farnsworth. Photoelectric Apparatus. (Filed, 1928)

Foreign Patents (British)

332,733 . . . To G. B. Ellis. Relating to P. E. Cells. (Filed, 1930)

333,548 . . . . To G. M. Walton. Relating to P. E. Cells. (Filed, 1929)

352,388, June 29, 1931; to P. M. G. Toulon. Photoelectric Apparatus. (Filed, 1929)

364,006, Dec. 28, 1931; to K. T. Bainbridge (British T.-H. Company). (Filed, 1929); also patented in Sweden, Aug. 26, 1930; No. 74,093 (German G. E. Assign)

410,142, Nov. 11, 1932; to W. F. Tedham (E.M.I., Ltd.)

413,954, Dec. 13, 1933; to F. C. P. Henroteau. (Filed, 1932)

Practical Volume Expansion

New realism in phonograph reproduction is secured by automatic means which extend the volume range at the reproducer. In England this device is known as "contrast" expansion, in America as volume expansion

By
C. M. SINNETT
RCA Manufacturing Co., Inc.
RCA Victor Division

THE design of equipment for reproducing music for entertainment in the home and in auditoriums has always met with serious problems dealing with limitations in dynamic range as well as frequency range. The limitation in frequency range has been somewhat overcome in the past few years, but to date no equipment for home use has succeeded in reproducing the dynamic range of a large symphony orchestra.

We learn from our study of music that a wide range of frequencies is often encountered in the rendition of a musical selection: the lowest note of an organ being as low as 16 cycles per second, and the highest overtone of an oboe being approximately 16,000 cycles per second. This range in frequency is much wider than that reproduced by the best grade of modern radio receivers, since in most receivers the range extends from about 60 cycles to 4,500 cycles. Modern electric phonographs cover a little more frequency range particularly at the higher frequencies. Results of listening tests, attended by famed musicians, indicate that for practical purposes this range meets present day requirements. In dynamic range, however, both the radio and the phonograph have definite limits falling far short of that encountered in a large symphony orchestra. The change in volume may extend over a range of 70 db from a pianissimo violin solo to a fortissimo ensemble. This dynamic range is much greater than that which can be satisfactorily reproduced by present day radios and phonographs. Such factors as noise in studio lines, tube noise in both transmitter and receiver, and distortion at high volume levels limit the dynamic range of a radio to about 55 db. In the case of the phonograph, this range is reduced to a maximum of 45 db, and this is available commercially only on latest process Victor Red Seal Records, because of the danger of overcutting the wax during recording and the presence of surface noise during reproduction. If it were possible to restore this loss of dynamic range, then a reproduction more nearly like the original would result. With the above limitations in mind, considerable development work has been carried on to increase the dynamic range of the phonograph.

Many systems which restore this dynamic range have been developed, but have been discarded, because they required a change in recording technique and a completely new library of records. The system about to be described depends for its action upon the variation in amplitude of recording, and gives a new sense of realism on any type of recorded symphonic music. In the development of a volume expander suitable for use in a commercial radio phonograph combination, several factors have to be considered such as cost, reliability, flexibility in production, and freedom from close limits of the components.

A Practical Volume Expander

Figure 2 is a schematic diagram of the volume expander used in RCA Victor Model D-22. Three of the new metal tubes are employed in this circuit. The 6L7 hexode-pentagrid converter is employed as a variable-gain voltage amplifier. The first 6C5 triode is resistance coupled to the second 6C5 and acts as a voltage amplifier and buffer tube between the input transformer and the second 6C5 which is connected as a rectifier, serving to furnish a bucking voltage for the bias appearing on No. 3 grid of the 6L7. In operation, the circuit functions essentially as follows: voltage from the electromagnetic pick-up appearing across the primary of the 1:80 step-up transformer is impressed on an aurally compensated volume control, and by means of coupling capacitor

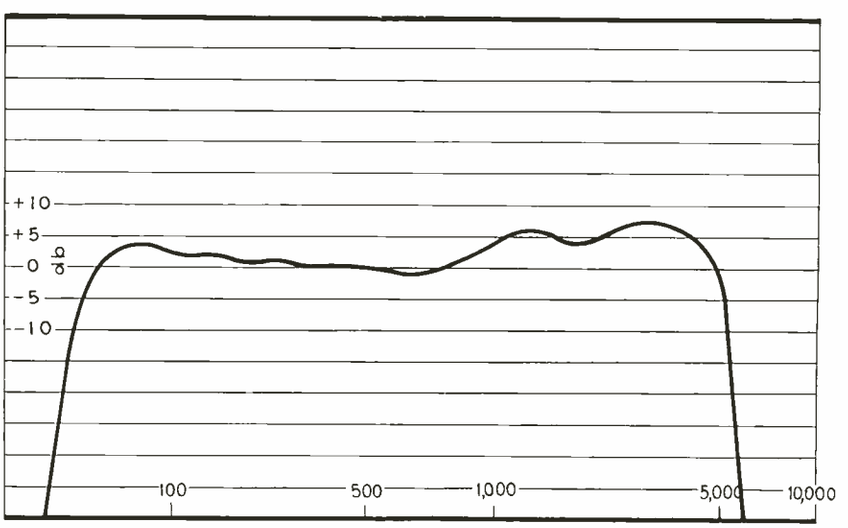


Fig. 1—Overall response characteristic; record to loudspeaker, Victor Model D22-1

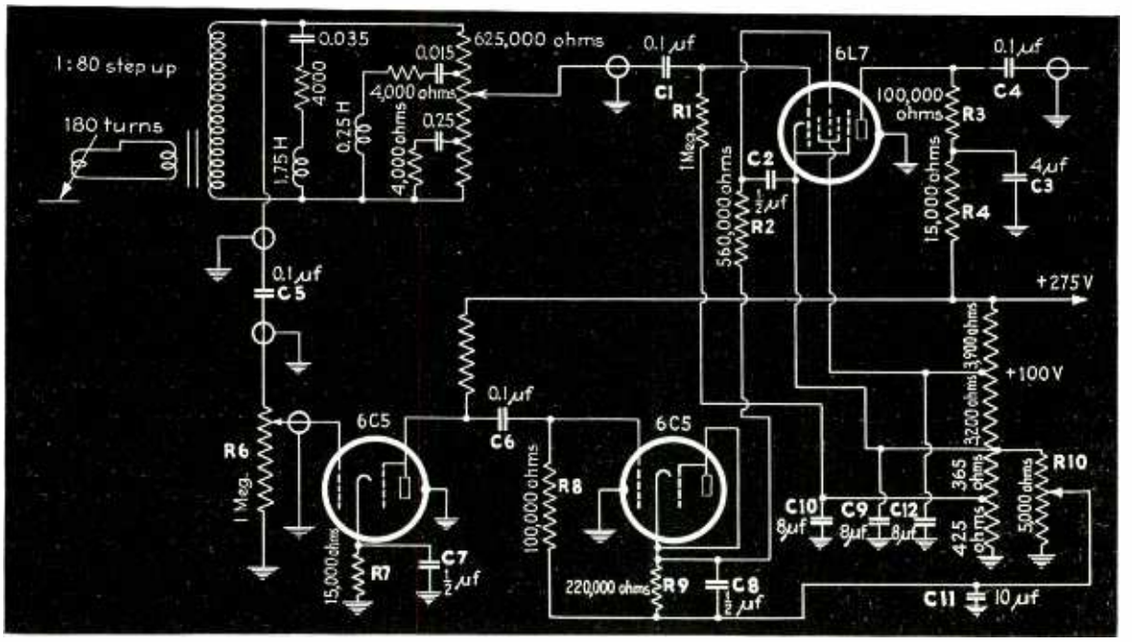


Fig. 2—Circuit diagram of volume expander as used in RCA Victor Model D-22 receiver

C_5, on the degree-of-expansion control R_6. It will be noted that the voltage delivered to expansion-control R_6 is taken off ahead of the signal volume control. This was considered desirable since it allowed any degree of expansion, which would be independent of any volume control setting. The variable-gain characteristic of the No. 3 grid of the 6L7 permits the use of this tube for volume expansion. The signal is impressed on No. 1 grid which is operating at a fixed bias of approximately minus 10 volts, obtained from the voltage drop across the 365 ohm section of the bleeder resistor. This method is to be preferred over self-bias, since self-biasing of this type tube would result in unstable action during volume expansion, and would cause the bias to vary greatly with different tubes.

Voltage impressed across the degree-of-expansion control R_6 is fed to the grid of the first 6C5 which has its plate circuit resistance coupled to the 6C5 rectifier. A 100,000 ohm plate resistor is used in the plate circuit of the 6C5 so that nearly maximum gain can be realized from this tube. The value of cathode by-pass condenser C_7 has been chosen as 0.5 μf to permit some degeneration to take place and thus reduce the low frequency response of this portion of the circuit. The curves in Fig. 3 show the frequency characteristic of the phonograph amplifier, as well as the frequency characteristic of the dynamic amplifier alone. This low frequency attenuation has been added so that low-frequency signals will not cause unnatural expansion such as would occur with normal frequency response characteristics in this type of an amplifier when base drum, tympani or base viol music were being reproduced. The second 6C5 acts as a simple diode rectifier and has a 220,000 ohm resistor in its cathode circuit. Voltage appearing across resistor R_7 is thus rectified and appears across resistor R_9 as direct current. Condenser C_8 of 0.5 μf capacity serves as a filter to smooth out pulsations in this rectified voltage. Resistor R_9 is connected in series with the bias supply to the No. 3 grid of the 6L7. A bias of approximately 18 volts negative is taken from resistor R_{10} which is adjustable. It is desirable to have this bias adjustable, because of the variations in tubes; optimum results are obtained when, with a screen voltage of 100 and a bias of 10 volts negative on No. 1 grid of the 6L7, a plate current of 0.12 to 0.15 ma. is obtained. This bias to the No. 3 grid also passes through the time delay and filter circuit composed of R_2 and C_2 having the values shown. The time-

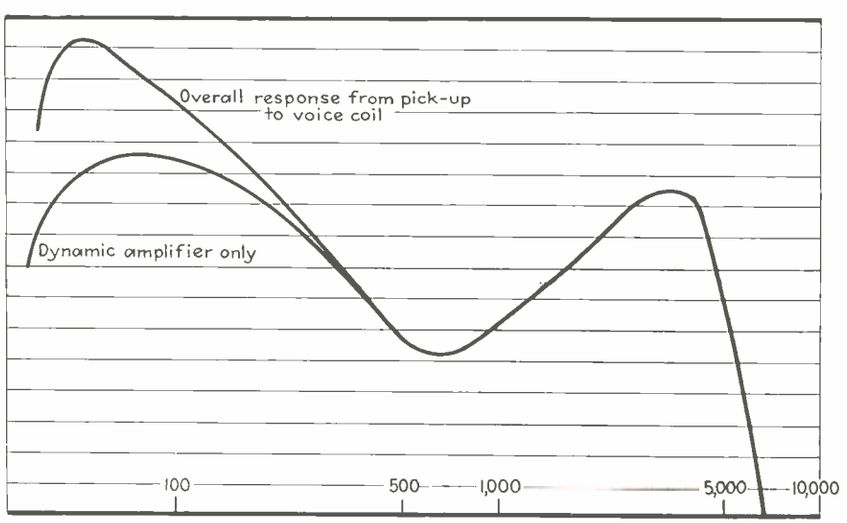


Fig. 3—Frequency characteristics of the phonograph and dynamic amplifiers

delay circuit is necessary that the operation of the expander may take place smoothly. If zero time delay were used then low frequency responses would gurgle and cause unnatural reproduction since the rectified impulses would bring about rapid changes in bias and correspondingly jerky performance. On the other hand too long a time delay would result in a smoothing out of staccato passages, and the overall effect of the expander would be nearly lost.

The values of R_2 and C_2, as shown in the time delay circuit in Fig. 2 were selected as a result of a great number of listening tests conducted during the development of the device. If it is desired that the time delay be a variable then R_2 should be made a variable resistor of approximately 1 meghom total resistance. This will permit variation of the time delay over wide limits. The time-delay circuit also prevents rectified "hash" from appearing in the main audio channel of the 6L7.

In duplicating the volume expander circuit shown, a hum-free voltage of approximately 275 volts across the bleeder will give the required voltages and by means of variable resistor R_{10} the plate current of the 6L7 can be adjusted to the required value. Output from the pick-up and transformer assembly should be of the order of 1.00 to 1.25 volts. The compensation of the input system will of course vary with different input transformers and pick-ups. Values shown are only for the particular instrument being described. It is evident from the diagram that the output of the 6L7 is fed to the grid of the next audio stage. For best performance, this stage should have a fixed gain of about 15, and should be coupled through a 1 to 3 ratio transformer to an output stage capable of at least 10 watts undistorted output. With the amount of expansion afforded in this particular amplifier, this power output is needed to permit the reproduction of distortionless expanded fortissimo passages, and yet allow the volume level of pianissimo passages to be a little above normal room level.

Figure 4 shows curves of output versus input—expanded and normal. As can be seen from the curve, the amount of expansion at very low levels is practically zero. With increases in input level, however, the amount of expansion increases until at maximum level a total expansion of approximately 20 db over the original is realized. This is within 5 db of that required to produce the dynamic range of a full orchestra, and is generally more than sufficient to produce a new sense of realism at normal output levels such as those used in the average home. Possibly a curve having a slightly different shape, particularly since records

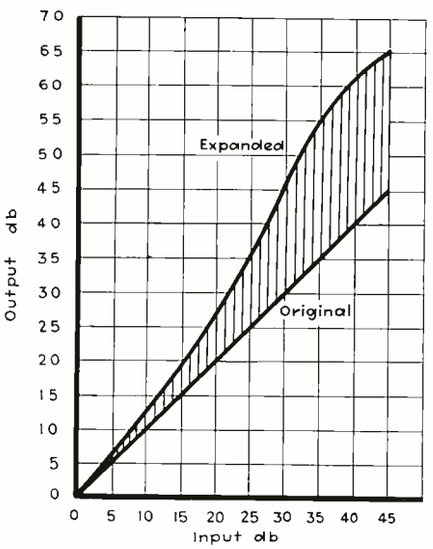


Fig. 4—Expansion amplitude of the commercial model

are manually monitored, would be nearer correct from a theoretical standpoint. Tests in the laboratory indicate that the advantages of a curve nearer the theoretically correct one are somewhat lost due to the variations in monitoring, and as a result the one shown has proven to be very satisfactory.

Apparent Noise Reduction

In demonstrating the expander, two strikingly different effects can be shown. If the maximum levels with and without the expander are adjusted to be the same, then the use of the expander will result in a material reduction of surface noise during low level passages. In other words, the low level passages are reduced about 20 db below the level which would be reproduced under normal conditions. This reduction in level, while it does not actually change the signal-to-surface noise ratio, gives the impression that there has been a definite change in this ratio, and the result is wholly pleasing. The other demonstration is equally effective, and consists of adjusting the low level passages to the same output with and without expansion. The high level passages will then increase to 20 db over the normal high level passages, and result in a much more realistic reproduction. Care must be taken with this particular demonstration, or the output stage will be driven to overload. Of course, a third demonstration in which the average level of reproduction is fairly high, with occasional passages at extremely low or high levels, will prove very interesting. In this particular case a change of plus or minus 10 db over the normal phonograph can be obtained by proper manipulation of the volume and expander controls before the test.

Figure 1 shows the overall response curve from record to loudspeaker output on Model D22-1. In taking this curve, a variable frequency record covering from 30 cycles to 10,000 cycles was used. This record, made specially for this purpose, was recorded with constant voltage on the cutter network, and is representative of the type of characteristic employed during the actual recording of an orchestra. From 800 cycles up, the record has been cut at essentially constant velocity; from 800 cycles down to 30 cycles, the recording has been made at constant amplitude. This method of recording results in an attenuation of output, when played, of approximately 15 db at 60 cycles. To compensate this attenuation, the fixed compensation across the secondary of the transformer has been designed for the particular pick-up and transformer used in the D22-1. The curve shown in Fig. 1 was obtained by rotating a microphone at a given distance from the two 12-inch speakers of the D22-1. It indicates a response flat within plus or minus 5 db from 55 to 5,200 cycles. The response curve of course trails off to lower and higher frequencies than those actually shown on the curve. Output can be heard from the loudspeakers as low as 30 cycles and higher than 10,000 cycles, but of course at a value much lower than through the mid-range.

Automatic Compression Possibilities

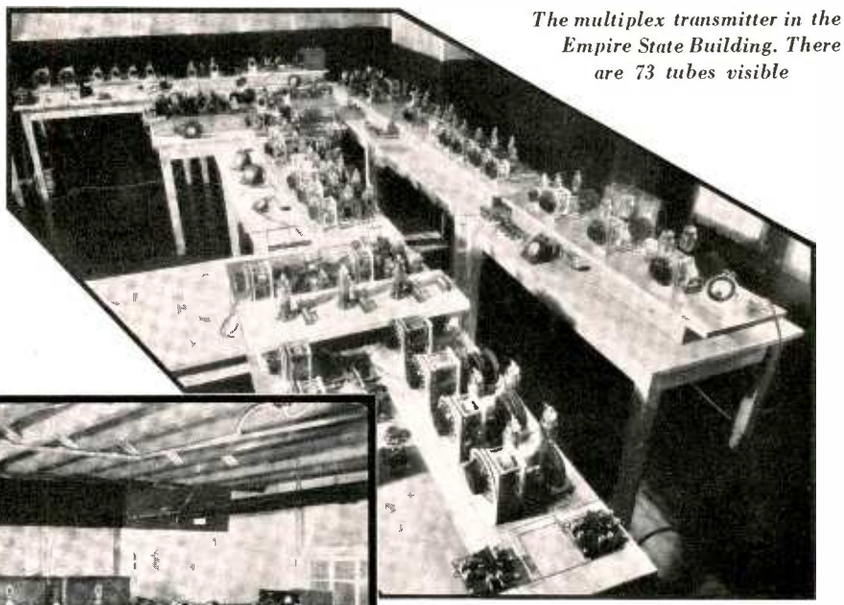
Model D22-1 for the first time makes available to the public a phonograph having a greater dynamic

[*Please turn to page 36*]

Phase-Frequency Modulation

Major E. H. Armstrong reveals to I.R.E. members the details of his new system, in which phase multiplication plays a leading role, and by which the ultra-high frequencies may be used over much greater distances and with less noise interference

SINCE April, 1935, when E. H. Armstrong announced to the press that he had a successful system of radio transmission by means of a frequency-modulated wave, details have been anxiously awaited. They were supplied at the November meeting of the Institute of Radio Engineers on November 6th. From the contents of that paper, and from an interview with Mr. Armstrong, *Electronics* has prepared the following review, for the benefit of those who did not attend the New York meeting. The complete paper will appear in the Proceedings of the I.R.E.



The multiplex transmitter in the Empire State Building. There are 73 tubes visible

The receiver at Haddonfield, mounted on Harry Sadenwater's workbench (note the brass rail)

Of primary interest are the results achieved. Briefly they may be stated as follows: Using the two-kilowatt 41-Mc transmitter of the NBC on the Empire State Building in New York City, frequency-modulated signals covering a total bandwidth of 150 kc. were sent to a specially constructed superheterodyne in Haddonfield, N. J. (near Philadelphia) 85 miles away, consistently for more than a year. Comparison of the quality and strength of the signals received were made with several 50 kw. broadcast stations operating between 600 and 900 kc. near New York. On numerous occasions it was possible to make comparisons using the same program, since the Empire State transmitter had access to NBC programs which were being transmitted by WJZ and WEAF. Under good atmospheric conditions, the frequency-modulated transmissions were distinctly superior, and under adverse conditions of noise and static, the frequency-modulated signals were clearly audible when the broadcast stations could not be picked up at all. On several occasions during severe thunderstorms, the frequency-modulated signals from 85 miles away could be heard more plainly than those from WCAU, a 50 kw. station only 20 miles away.

Frequency modulation differs from the universally used amplitude modulation in that the amplitude of the emitted frequencies remains constant regardless of the depth of modulation or of the value of modulation frequency, while the carrier is caused to shift in frequency by an amount proportional to the depth of modulation and at a rate corresponding to the modulation frequency. In the apparatus described by Mr. Armstrong, for example, the carrier frequency deviated from its normal position by 75 kc. on either side of the 41 Mc. center under full modulation, and this deviation occurred 5,000 times per second when the modulation frequency was 5,000 cps.

One advantage of such transmissions is the fact that the transmitter is always operating at optimum efficiency (full output of the final amplifier), whereas in amplitude modulation, the peak power is four times the unmodulated power, with attendant requirements for tubes and power supply. The disadvantages are the apparent complexity of the

transmitter and receiver, and the wide frequency band required. It is to be remarked that the degree of frequency modulation employed in the f-m system is considerably less than that inadvertently introduced by almost all self-excited amateur transmitters now using "amplitude" modulation on the 60 Mc. (5 meter) band.

The complexity of the transmitter cannot be gainsaid; it contains, (in addition to a crystal oscillator, balanced modulators, and amplifiers) no less than 10 multiplying stages and 6 buffer-filter stages. The original receiver contained three r-f (41 Mc.) stages, followed by a converter to 6 Mc, followed by an i-f gain of 2,000, followed by a second conversion to 400 kc., followed by a second i-f gain of 1,000, followed by current limiters, conversion amplifiers and rectifiers, and the audio output stages. Later, by the use of an acorn tube in the r-f, two tubes were eliminated, leaving a total of approximately 25. Mr. Armstrong believes that further simplification can be secured, and reminds old timers that the original superheterodyne had 37 controls, which have since been happily reduced (in the case of the cigar-box midget) to about 0.5.

The Transmitter Problem

According to the paper, "During the course of this work there was evolved a method which, it is believed, is a complete solution of the transmitter problem." This involved (1) stable central frequency ("carrier" or "unmodulated" frequency); (2) frequency deviation independent of modulation frequency, but proportional to the latter's amplitude; (3) linearity throughout; (4) the use of aperiodic circuits to eliminate resonance troubles; (5) the achievement of frequency deviations of the order of 200 kc. without violating any of the foregoing conditions.

The solution of this formidable array of requirements was found by the use of a small phase shift produced in the output of a constant-frequency oscillator. This phase shift, not more than 30° maximum, is made proportional to the amplitude of modulating current, and, for reasons given below, also inversely proportional to the modulating frequency. The constant-frequency oscillation with its variable phase angle is then fed to a series of frequency multipliers which multiply the frequency and its phase shift at the same time. After multiplication to 41 Mc., the phase angle is large enough to cause 100% frequency modulation for the highest modulation frequency, corresponding to a 75 kc. deviation on either side of the carrier or 150 kc. total band-width.

It is to be noted that if the phase shift were not inversely proportional to the modulation frequency, the final frequency deviation would be proportional to the modulation frequency, which is a violation of requirement (2), above. The inverse proportionality in the phase shift produces independence of modulation frequency in the frequency deviation of the emitted signal. The phase shift is made inversely proportional to modulation frequency by the use of a condenser shunted across the grid of the speech amplifier, used in conjunction with a series resistor.

The phase shift apparatus (Fig. 1) follows: The output of an oscillator (50 to 100 kc. crystal-controlled) is fed to a linear amplifier and to the grids of a balanced modulator. The modulator is suppressor modulated by the speech input. The output of the balanced modulator contains the sidebands (oscillator frequency plus and minus modulation frequency). These are then given a 90° phase shift through the output transformer, amplified and returned to resistor *R*, common to the side-band amplifier and the linear amplifier. The voltage across this common plate resistor *R* has the master frequency and a phase which is proportional to the side-band (modulation) amplitude, and, by the mechanism explained above, inversely proportional to the modulation frequency. An isolating amplifier feeds this voltage to the cascaded doublers, which proceed to multiply the frequency and phase by several thousand times. This multiplication process is not critical or unstable and no great linearity precautions need be taken.

Spurious frequencies must be eliminated at each multiplication, hence the need for buffer-filter stages, but otherwise the process is completely straight-forward.

All of the tubes used in this set-up, except the last four or five stages, are receiving tubes. The reduction of cost thereby introduced is considerable, there being no less than 73 tubes in the transmitter, as used for multiplex work. But 73 tubes or no, a "complete solution" of the transmitter has been achieved therein. The transmitter, considering its complexity, is a miracle of stability.

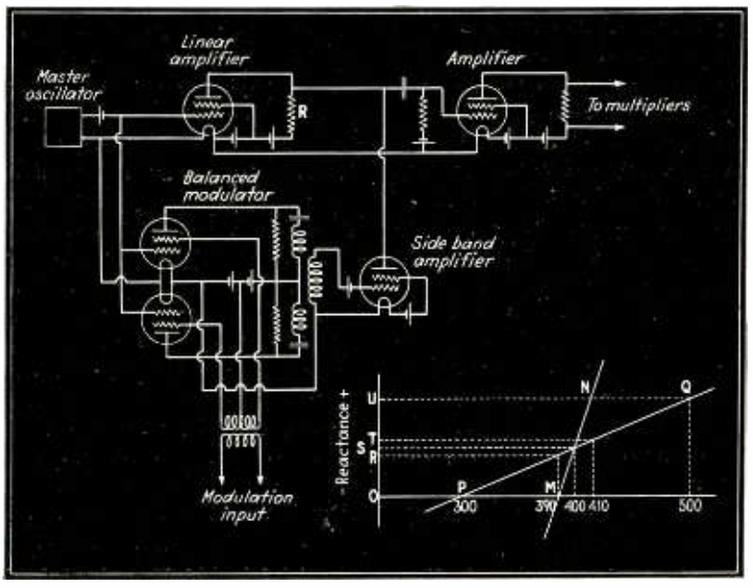


Fig. 1—Diagram of the phase-changing apparatus in the transmitter. Insert —diagrammatic analysis of the anti-noise action

The Receiver Problem

A major difficulty lay in the design of a receiver to translate the frequency modulation into amplitude modulation, with high fidelity, and without admitting noise. Two alter-

native methods of achieving this end have been developed, both of which operate on the same essential principle. For the sake of simplicity only one will be described. The received signal (picked up on a half-wave vertical dipole antenna) is fed through r-f amplifiers and two wide-band (150 kc.) i-f amplifiers of 6 and 0.4 Mc. frequency. The output of the final i-f amplifier is fed to the conversion circuit (Fig. 2). The combinations of resistances, inductance and condensers R, L, C, and R', L', C' convert the imposed frequency modulations into amplitude modulations by the clever expedient of having L and C resonate at the lower limit F_1 of the 150-kc. i-f band-pass, while L' and C' resonate at the upper end F_2 of the band. The resistances R and R' are large enough to make the current in each branch substantially constant over the frequency band. Under such conditions, the reactance across each branch is given by A and B in. Fig. 2. Because of the constant current, the voltage across this reactance is thus given by A' and B' also in Fig. 2. It will be seen that the voltage has the required change in amplitude as the frequency is varied from F_0 on either side to F_1 and F_2. This voltage is fed through amplifiers to linear rectifiers. The outputs of the rectifiers are connected in the proper polarity so that current changes produced by frequency changes are added. The net rectifier current is then coupled to a suitable audio system for loudspeaker reproduction.

Current-limiting devices (a.v.c.) are incorporated in the receiver for the double purpose of aiding the anti-noise action, and providing a constant level. Fading was quite noticeable over the 85 mile path but selective fading was not observed, so that the a.v.c. held the level constant without distortion. The quality of the circuit can be realized from the fact that when the telephone lines from the studio to the Empire State transmitter were compensated to 13,000 cps, the quality of reproduction from a loudspeaker at the receiving end was then substantially better than that obtainable on a high-fidelity receiver from any regular broadcast station.

The system has been used for some time as a multiplex circuit, both the Red and Blue network programs being sent simultaneously on the same channel without difficulty. Multiplexing requires a wider channel than simplex transmission, but no great difficulty was found in handling a modulation range of 30,000 cps., for multiplex purposes.

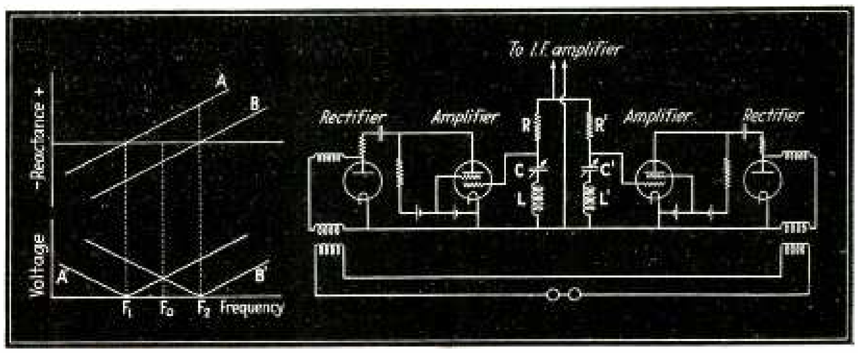


Fig. 2—Conversion circuit of the receiver (converts frequency variations to amplitude variations). Left, the frequency characterstics of R,L,C and R'L'C'

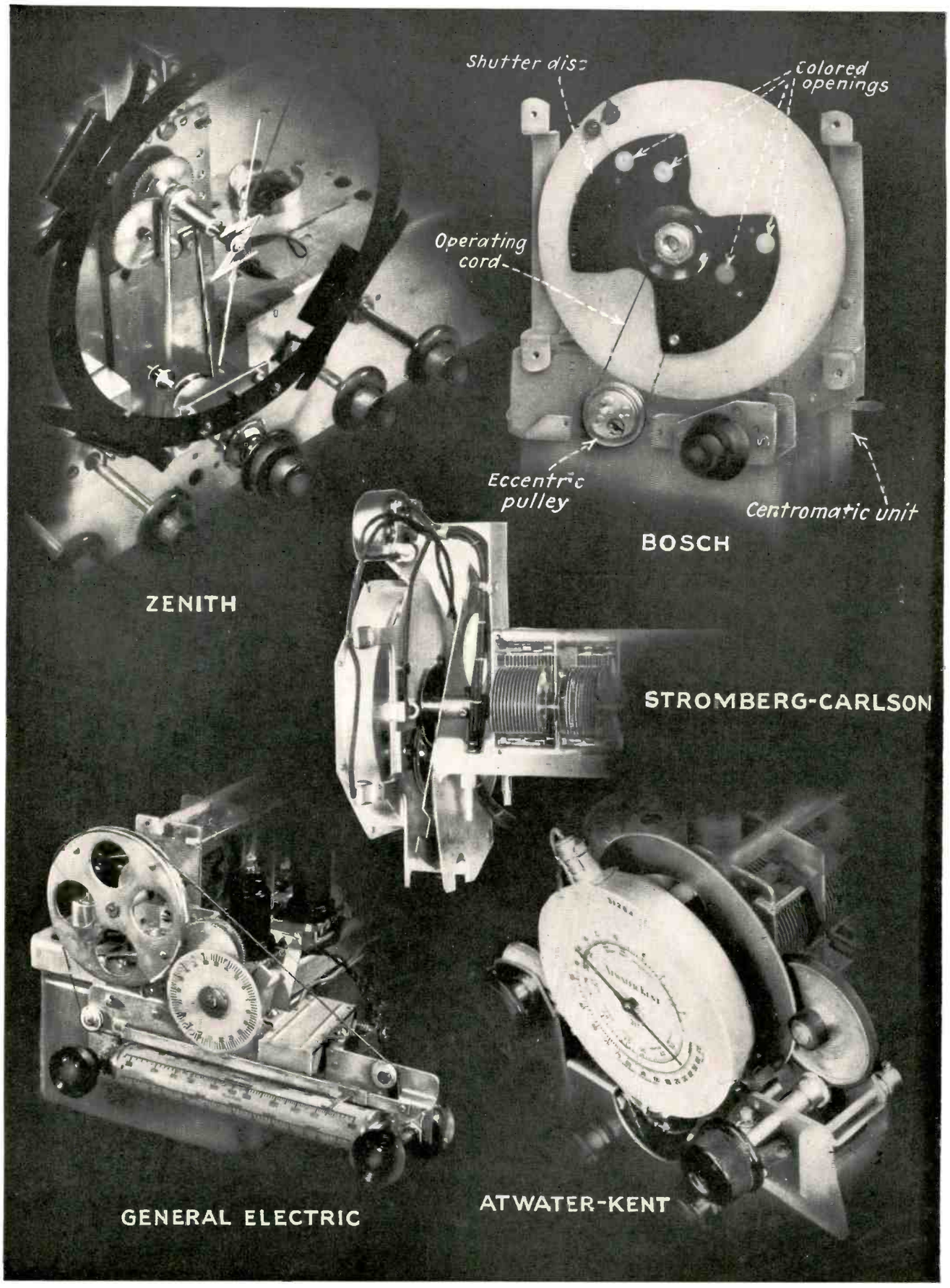
Why the Signal-to-noise Improvement?

The fact that a practical frequency modulation system has been devised and that it permits an improvement in some respects over amplitude modulation methods, at least on the ultra-high frequencies, would be in itself sufficient justification for the report were it not for the extraordinary interest in the effect of the new system on the signal-to-noise ratio. This interest has arisen partly because of the practical nature of results obtained, but mostly because the results are a contradiction of the long-accepted theory that the noise received is proportional to the band-width received. This theory has been substantiated by amplitude-modulation receivers. It is clear, however, that in the last analysis, only audible noise (as high as 20,000 cps) is troublesome. Thus as the received band is widened, the audible noise reaches a limit. When the band is 20 kc. wide, the highest frequency (beats between the limits of the band) is 20 kc. Increasing the band width beyond this point does not increase the audible noise. Hence the 150 kc. band used in the Armstrong system could contribute no more audible noise than a 20 kc. amplitude-modulated channel. Actually it contributes considerably less noise.

To use Armstrong's words, "The basis of the method (of improving signal-to-noise ratio) consists in introducing into the transmitted wave a characteristic which cannot be reproduced in disturbances of natural origin and utilizing a receiving means which is substantially not responsive to currents resulting from the ordinary types of disturbance and fully responsive only to the type of wave which has the special characteristic."

The insert in Fig. 1 is the key to the noise problem. Suppose the selective system (Fig. 2) has a slope MN so that 100 per cent modulation is produced by a frequency shift of 10 kc. either side of the 400 kc. carrier. Noise components of frequency 390 and 410 will be zero and proportional to UO, respectively, their difference being UO. Now if a wider band is used, with a selective circuit of slope PQ, the noise components of frequency 390 and 410 will be but little different from the 400 kc. carrier. The difference in value of the two noise frequencies is proportional to RT. Hence the noise produced with slope PQ will be related to the noise produced with slope MN as RT/UO, or 10 per cent for the values given in this case. The power ratio is 1 per cent. Thus, the wider the band over which the system operates, the less the noise in relation to the signal which is always UO. It is necessary for the noise components at 390 and 410 cps. to be opposite in phase; this requirement is met by the current limiting circuit which precedes the selective system, and which produces the 410 component as an "image" for the 390 component. Noise frequencies more widely removed from the carrier will not have as good a correction, but these are above the audible limit and may be removed with filters without loss of fidelity. The same analysis holds true when the 400 kc. carrier frequency is varied according to the modulation at the transmitter.

[*Continued on page 36*]



Belts, gears, cords, cams, links and pulleys—make up radio tuning dial mechanisms

Dial Mechanisms

Radio sets must be tuned and many devices have plagued the set owner to that end. 1936 sees many types of dials and mechanisms, some new, some old, all of interest

ALL-WAVE receivers have emphasized acutely the tuning problem. A dial that provides good control over the gang condenser on the domestic broadcast band will not suffice at all when the listener wants London or Madrid. On the following pages are shown and described some of the various tuning systems used in the new receivers.

Atwater Kent Tuning Mechanisms

Receivers of Atwater Kent have been noteworthy for a smoothness and ease of tuning, with absence of backlash or sticking. This, of course, is partly a matter of workmanship, but it is largely due to the use of a rubber to metal rather than a metal to metal contact in the gears.

The type of two-speed tuning mechanism used this year is distinctively Atwater Kent, as the change from one tuning ratio to the other is accomplished by merely moving the tuning knob up or down about one-quarter inch instead of in or out. The upper position gives the rapid movement desirable for broadcast tuning or for quickly reaching another part of the scale, while a downward pressure on the knob, without changing the position of the hand, quickly shifts to the slow speed ratio where the great smoothness and gradual movement required for short wave tuning are obtained.

In all cases the entire tuning gear assembly is mounted in a pivoted or rocking frame which is held in either the up or down position by a detent spring.

When the gear assembly is on the down or short wave position, the drive is double reduction from a small spiral toothed gear on the tuning shaft through a counter shaft having rubber rimmed gears, and giving a tuning ratio of 74 to 1.

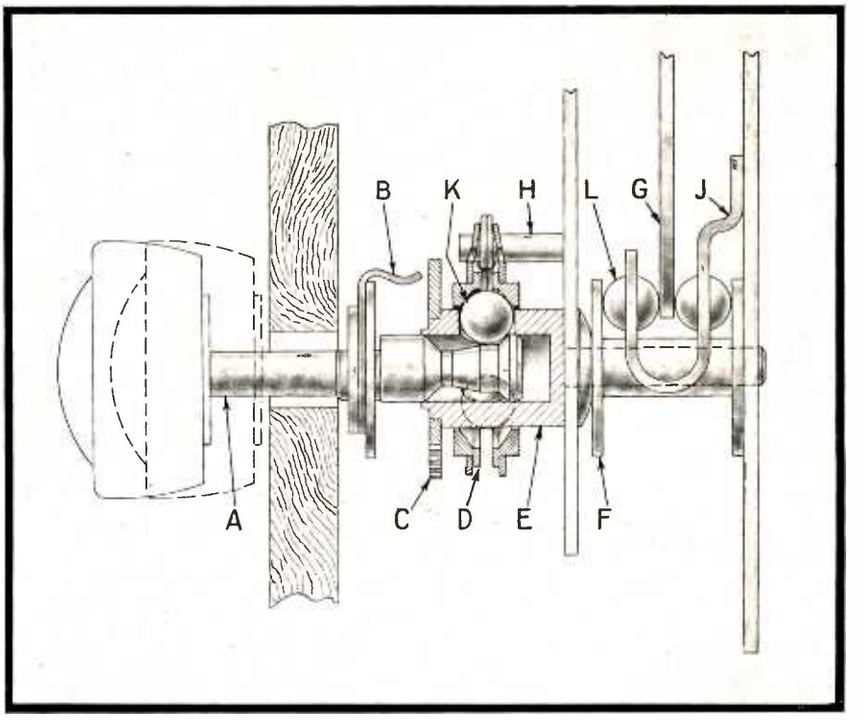
Upward pressure on the tuning knob snaps the entire gear assembly to a position where the counter shaft is disengaged and the drive is direct from a spiral toothed gear on the tuning shaft, through a rubber idler to the large gear on the condenser shaft; giving a broadcast tuning ratio of about 8 to 1.

The illumination of the three-scale dial is controlled by the range switch in such a way that when the short-wave scale is in use the upper half only is illuminated and the lower half only when the police scale is used. When the broadcast scale is used the whole dial is illuminated.

In the larger sets, the same two-speed tuning gear assembly is used as in the smaller sets, but the aeroplane dial is replaced by a dial which slides vertically, being inter-connected with the range switch in such a way that the broadcast, police, or particular short wave scale desired appears in the escutcheon window as the range switch is turned to each corresponding position, no other scales being visible.

On these scales the graduations are substantially uniform in spacing from end to end instead of being much spread out at one end and badly congested at the other so that alternate graduations have to be omitted. The broadcast scale is uniformly subdivided into 10-kc. graduations, and the short wave scales into 1/10 Mc. throughout.

The pointer is driven by a crank pin carried by the condenser shaft working in a curved slot in the pointer arm, giving the pointer a movement of 90 degrees, while the condenser turns through 180 degrees. The relation between the movements of pointer and condenser is not uniform, however, the action of the slot curvature being to give a "band spread" effect to what would otherwise be the congested end of the scale. This compensating pointer mechanism has the effect of doubling the tuning ratio so that while the two ratios are 6 and 60 relative to



Cross-section RCA Victor dual ratio drive mechanism

the condenser, the effective ratios between tuning knob and pointer are 12 and 120 respectively.

The comparatively flat curvature of the 90-degree dial overcomes the difficulty that exists in reading the ends of the 180 degree dials commonly used.

G.E. Tuning Mechanism

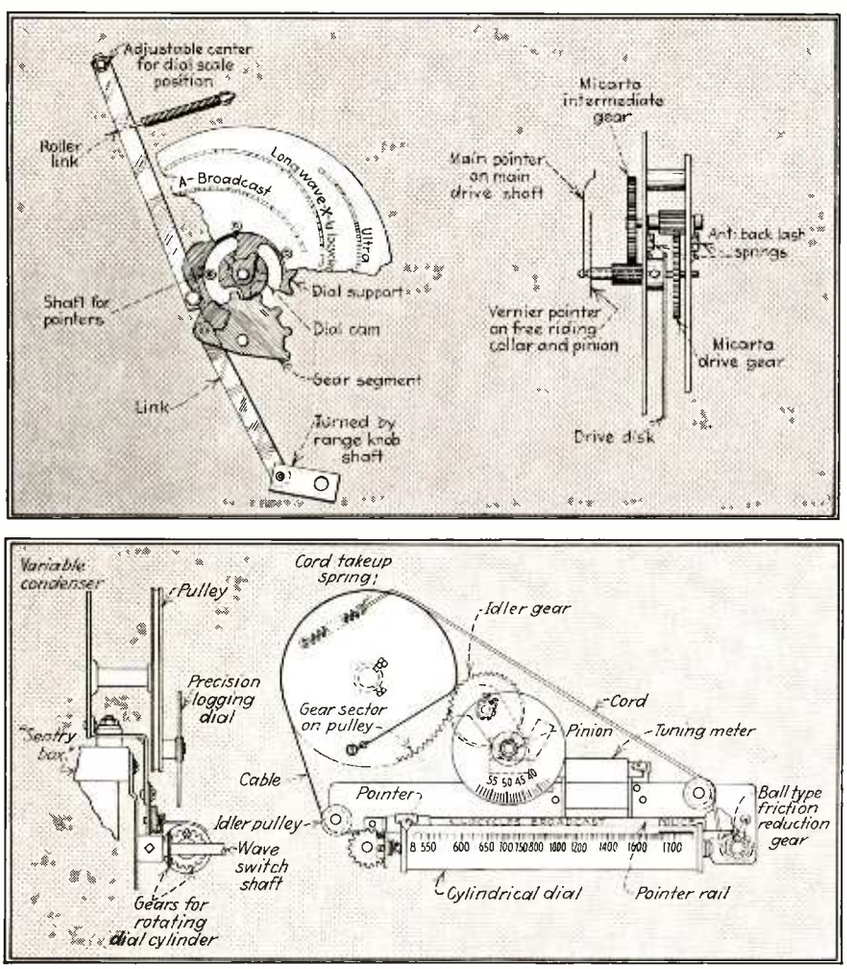
In designing the tuning mechanism for the new General Electric receivers particular attention was paid to the requirements of ease and convenience of operation, accuracy and permanence of calibration, visibility and legibility of dial markings, definite indication of the setting of the band switch, and pleasing appearance.

On models A-125 and A-205, the dials and control knobs are arranged according to their functions. The main tuning dial occupies the central position, with the tuning control knob on the right and the band change switch knob on the left. The precision tuning indicator and the tuning meter screen are visible through two small windows above the main dial. The escutcheon which ties these control elements together into a unified group is designed to harmonize with the cabinet in design and finish. A curved, transparent window covers the tuning scale and pointer and protects them from damage. In a lower row are the bass tone, sensitivity, volume and treble tone controls respectively.

The calibrations for the various frequency bands are printed in parallel lines on the surface of a cylinder, two to five such scales being provided, depending on the range of the receiver. This cylinder is geared to rotate in unison with the wave-change switch so that only one scale is visible at a time, thereby obviating the confusion which obtains when several scales are visible simultaneously. The scale in use is always located on an upper segment of the cylinder, thus providing equal visibility from either a standing or a sitting position.

As the scales are all straight horizontal lines, all of the figures are upright, and may be read from end to end without changing the eye-point. The pilot lamps are placed at the rear of the cylinder, so that the light, passing through the rear wall is diffused, and illuminates the scales uniformly. The pointer is broad at the top, to catch the attention, yet sharp at the end to provide accurate indication.

The variable condenser is driven by means of a dual-ratio reduction drive which has provision for automatically selecting the most advantageous ratio. As the receiver is tuned, the pointer moves rapidly, traversing the entire length of the scale in about four revolutions of the knob. With this low ratio it is natural that the receiver will be tuned to a point slightly beyond the desired station channel. As the motion is reversed to correct the tuning, the reduction ratio is automatically increased to about 50 to 1, making it possible to tune with great precision. This makes it unnecessary for the user to think about choosing between two available ratios, and makes it virtually impossible to tune in with the low ratio, thus insuring more accurate tuning. The initial reduction is effected by means of a belt drive between the variable condenser and the friction reduction gear on the knob shaft. This belt, which also drives the pointer, consists of a metallic cable between the condenser pulley and the pointer, in order to prevent change in calibration due to elongation. The remainder of the belt, which is provided with a take-up spring, is of impregnated silk to provide the necessary driving friction on the small V-pulley. The friction gear, of the planetary ball bearing type, has a ratio of 9 to 1, and is provided with an automatic shift to unit ratio for rapid tuning. For approximately one revolution of the tuning knob, the condenser is driven through the combined ratios of the belt and the friction gear. At either end of this motion, the pin on the shaft engages the cam on the pulley member, thus short-circuiting the planetary reduction. The action of the cam also lifts the shaft away from the three balls, and allows the pulley member to move freely within the stationary outer races. When the



Selector dial drive and band-spread mechanisms of RCA Victor Details of the General Electric cylindrical dial

rotation of the knob is reversed, the cam and the pin disengage, reinstating the high ratio for fine tuning.

To make possible the logging of stations which are very close together on the main tuning dial, an auxiliary dial is provided which is coupled to the tuning condenser through an anti-backlash overdrive gearing. Because of its rapid rotation, this dial has an effective scale length of about four feet.

The tuning meter is of the "ladder" type, so called because a number of vertical shadow lines, spaced like the rungs of a ladder, advance from left to right across the screen as the receiver is brought to a point of resonance. As a number of the shadow bars may traverse the screen as a signal is tuned in, the meter is more sensitive than the conventional type with the same length of scale.

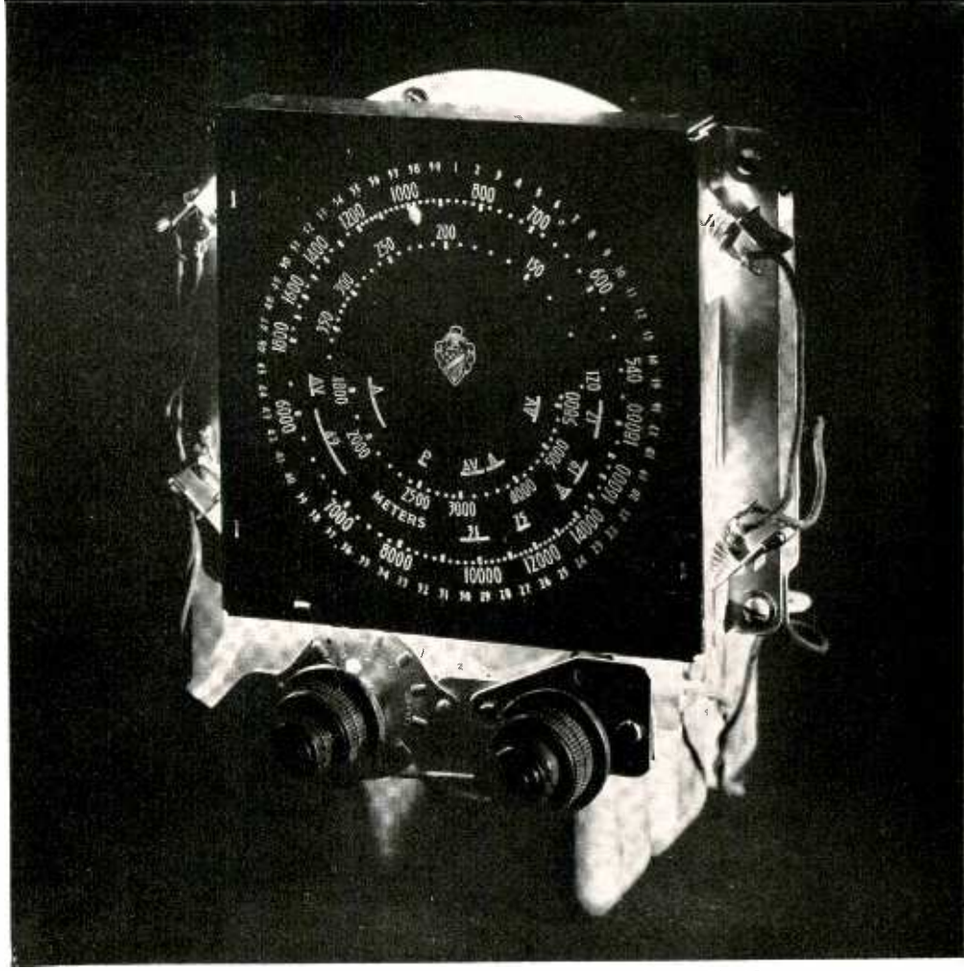
Sparks-Withington Drive

The dial for the selector drives is calibrated from 530 kc. to 20 Mc. This spectrum is divided into four bands arranged on the dial with two on the upper half and two on the lower half. The dial colors and calibrations correspond with a band-selector switch mounted on the front of the panel so that the position of this switch will be indicated in colors (either a colored dot or a colored light) which in turn corresponds with that color on the dial.

All of the mechanisms employ a planetary drive which provides a reduction ratio from the knob and this, in turn, is subject to a further ratio reduction through a friction drive as well as a gear drive. The overall ratio varies with the models. The planetary drive is so constructed that the large knob on the panel operates the dial pointer without using the planetary drive reduction and in this way there is provided high speed and low speed tuning.

RCA Victor Mechanisms

In the Magic Brain Radios, a new tuning mechanism embodies, all in one unit, means for indicating the frequency to which the set is tuned, an additional vernier pointer and scale for more accurate reading and tuning, and means for automatically changing the dial scale so only that which corresponds to the particular position of the range switch is visible. The mechanism also provides dual-ratio tuning means employing a push-pull clutch which when pushed in, tunes ten-to-one from the knob to the condenser rotor and when pulled out, tunes fifty-to-one respectively.



United American Bosch dial showing illumination from all sides

Mechanical undesirables such as backlash between indication and tuning have been eliminated. Tuning is accomplished through a ball-bearing friction mechanism while the vernier pointer is driven from the condenser shaft through a spur gear train for the purpose of maintaining accurate register to permit logging of stations. The sub-panel displays an etched vernier dial scale and a semi-circular window through which the various calibrated dial scales are visible in turn as the position of the band switch is changed. The dial scales are all printed on one translucent disc which is made to revolve, being actuated by a segment gear and link connected to the range switch. An ingenious layout of the printing makes possible this novel means of displaying separate scales for the individual bands.

On the selector dial drive mechanism the printed multi-scale dial is riveted to a die cast cam, having indentations and interconnecting cam faces for accurate register of each position by means of the engagement of the spring actuated roller link. This dial cam is rotatably mounted on a fixed shaft and is made to rotate by manually turning the range switch knob through the arm, link and gear segment. The gear segment is of spread toothed design and meshes with similar teeth cast integral with the dial cam. Lost motion is provided in the mesh of the teeth to permit the roller link to register the dial scale position accurately by engaging the equally spaced indentations in the cam. The shaft of the dial scale is disposed laterally from the pointer shaft in such a manner as to position the active semi-circular scale concentric with the pointer shaft.

The band spreader or vernier pointer mechanism is seen to be driven through a compound spur gear train having anti-backlash springs arranged to eliminate gear-tooth backlash.

The operation of the dual ratio planetary ball-bearing drive is seen by reference to the cross sectional view. The shaft (A) carrying the knob, when in the position shown in

solid lines and when rotated, transmits a planetary movement to the balls (K). The orbit of this movement is controlled by the non-rotating self-centering cone race assembly (D). Rotation of K is prevented by a notch integral with the cone race springs being engaged with a stationary pin (H). By reason of the planetary balls (K) being retained in three radial holes in the hub (E), a reduced speed rotation of five to one is imparted to hub (E). Securely fastened to hub (E), is a spring washer assembly (F) dimensionally designed to press the balls (L) and disc (G) together and at the same time to transmit rotary motion thereto. This provides a further speed reduction from the hub (E) to the disc (G) of ten to one, thus affording an overall reduction of fifty to one from the shaft (A) to the disc (G). The knob and shaft (A) may at the discretion of the operator be pushed into that position shown in dotted lines. This action engages the clutch fingers (B), securely fastened to shaft (A), with a saw-toothed clutch wheel (C) which is likewise securely fastened to hub (E). Since this shift locks (A) & (E) together and simultaneously releases the planetary balls (K) from engagement with the cone races, the speed reduction is now only ten to one.

The Bosch Arrangement

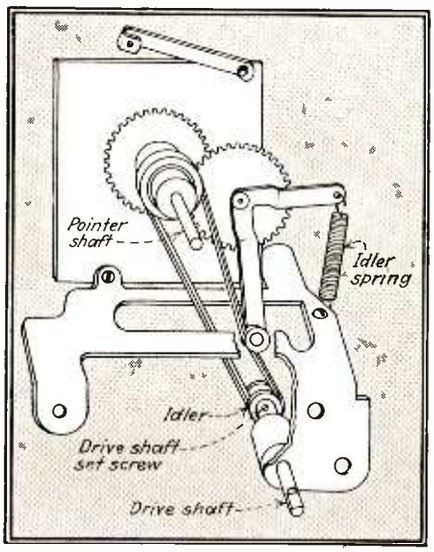
In the United American Bosch receivers Model 595, the dial mechanism is mounted directly on the Centromatic unit. A two-speed vernier station selector knob drives the gang condenser through a rubber idler roller which bears against the edge of a knurled disc on the condenser shaft.

The dial is of etched glass illuminated from the edges. It is backed with black except for areas through which the illuminated indicators or pointers are seen. Only the indicator for the scale corresponding to the band in use is illuminated. This is accomplished by means of light reflected through a translucent colored opening back of the indicator hole in use.

Since a different indicator color is used for each band, confusion in reading the proper dial scale is avoided.

Back of the glass dial is a black disc attached to the condenser shaft with openings as indicators for each band. Back of this first disc is a butterfly or shutter disc with translucent colored openings so arranged that only one at a time registers with an indicating opening.

During tuning, the two discs turn together but the angular relation between them is changed when shifting bands. This angular relation is determined by an eccentric pulley operated by the wave change switch. The center distance of this pulley from the condenser shaft fixes the active length of a shutter operating cord. This cord is passed over the eccentric pulley. One end is attached to a hub on the condenser shaft and the other to a hub on the shutter disc. A single spring between the two hubs keeps the cord tight.



Wells-Gardner drive mechanism

Stromberg-Carlson Selectorlite Dial

This is the original multi-range dial that directly indicates the range or scale which is in service, by illuminating only the particular section of the dial to which the range switch is set. Dial lamps are provided for each range and the illumination for each dial scale is confined to the particular area of the dial by metal partitions located at the back of the dial. Contacts on the range switch control the several dial lamp circuits, thus providing individual dial scale indication as well as illumination. In addition to the convenience of this scheme of dial scale selection, there are no levers, moving scales or other mechanical parts involved, thus doing away with moving parts that may produce rattles or other disturbing noises when operating the receiver at high volume levels. The scales and markings on this dial are made large so as to be easily read with the operator's eyes located at a comfortable distance from the radio cabinet. The dial scales are on a special laminated Phenotic material of pleasing neutral shade that blends with the brown walnut finish of a radio cabinet. The radio channel selection is made with a long double pointer or hand which is fastened directly to a projection of the tuning capacitor shaft, insuring positive indication at all times. An auxiliary pointer (second hand) is provided to enable the user to identify closely crowded stations on the short-wave ranges of the dial. This single second-hand pointer is driven by special gearing, with means to avoid back lash, so as to rotate approximately 13 times the rotation of the channel selector hand. The scale for this second hand is located around the center section of the dial so as to avoid confusing the operator.

Another novel feature of this dial is the method of obtaining the equivalent of two-speed drive from the knob, without the use of gear or ball reduction mechanism. This is done by using a double-stepped knob, the small center portion being designed for spinning between the thumb and front finger, for rapidly moving the pointer over the scale, and a comparatively large diameter outer rim of the knob for slow movement of the pointer when tuning short-wave stations.

Going from the rapid to the slow movement requires only that the operator's fingers be raised from the small diameter part of the double knob to the outer or large diameter portion. Here again extra mechanism is avoided and simplicity of operation provided.

EDITOR'S NOTE — *In preparing this material on dials and mechanisms, the editors were aided by L. F. Curtis of United American Bosch, Karl Hassel of Zenith, D. R. DeTar of General Electric, John H. Teaf of RCA Victor, R. H. Manson of Stromberg-Carlson, Sarkes Tarzian of Atwater Kent, and J. K. Rose of Wells-Gardner.*

Broadcast Maintenance Costs

Annual replacement, depreciation, and salary figures reported by 86 United States broadcast stations of from 100 to 50,000 watts power, the results of a questionnaire-survey recently undertaken by *Electronics*

THE fact that the broadcast stations of America spend in excess of $10,000,000 per year for operation and upkeep is revealed by the results of a questionnaire-survey recently completed by *Electronics*. This figure is based on estimates supplied by approximately 15 per cent of the active broadcast stations in the United States.

Questionnaires requested information on the cost of electric power used in the transmitter and the auxiliaries, the annual replacement cost of equipment such as tubes, batteries, microphones, etc., equipment obsolescence and station depreciation, and salaries paid to the technical staff. The 86 replies received were first classified according to the power of the stations, and the figures reported in each classification were then averaged, with the results shown in the table below. At least ten per cent of all of the broadcasting stations in the different power groups participated in the survey, so that the figures given can be taken as representative of all stations in that particular classification.

In addition it is possible to estimate the total annual market for various types of equipment in the broadcast field on the basis of the figures given. This latter calculation may be made by multiplying the total number of units used by all broadcast stations by the average price per unit. The table given above represents market values estimated by this method.

By multiplying the total annual maintenance cost for a station of given power by the number of broadcast stations in each power classification, the total upkeep expense of the broadcasting industry may be estimated; the figure thus calculated is $10,800,000.

The editors of *Electronics* wish to express their appreciation of the help given by the broadcast stations that participated in this survey.

THE BROADCAST STATION MARKET

Item	Units	Annual dollar volume
Tubes over five watts	25,000	$900,000
Microphones and studio equipment	3,500	175,000
Transformers and modulation equipment	.....	75,000*
Antenna Towers	.....	75,000*
Tubes under five watts	18,000	55,000
Dry batteries	17,000	35,000
Storage batteries	2,000	30,000
Antenna wire	.....	12,000*
Transmitters	.....	$3,720,000†

*These figures estimated, since replies concerning these classes of equipment were largely incomplete.

†This figure is the total annual depreciation charge of the broadcast industry. It represents roughly the annual market for new transmitters including installation and studios.

AVERAGE ANNUAL MAINTENANCE FIGURES REPORTED BY BROADCAST STATIONS

Power rating (watts)	Cost of power (dollars)	*Power tubes		Small tubes		Storage batteries		Dry batteries	
		Number	Cost ($)	Number	Cost ($)	Units	Cost ($)	Units	Cost ($)
100	465	9	350	21	55	3	37	25	40
250	580	11	450	39	52	2	45	29	48
500	1,170	13	913	23	61	4	54	17	40
1,000	1,810	19	1,790	37	149	6	59	40	70
2,500	3,750	20	2,020	12	207	3	34	24	91
5,000	3,450	14	2,530	35	103	3	79	55	80
10,000	4,300	15	1,930	60	88	3	22	48	30
50,000	20,250	43	11,000	59	198	4	123	30	232

*Five watts and over.

Power (watts)	Microphones, etc.		Depreciation (dollars)	Life of Equipment* (years)	Salaries to technical staff ($)	Total Maintenance Cost ($)
	Units	Cost ($)				
100	4	81	1,430	6.2	3,750	6,208
250	5	277	1,300	8.5	4,230	6,920
500	8	264	3,590	6.2	6,380	12,472
1,000	6	173	5,284	10.3	8,570	17,905
2,500	11	200	.....	6.0	11,300	17,602†
5,000	3	560	5,000	5.0	8,412	20,214
10,000	1	75	.....	5.0	7,282	13,727†
50,000	5	2,125	63,320	5.2	31,600	128,798

*Depreciation period. †Less depreciation.

High-fidelity Technique

Being a series of reports made to the FCC by station W2XR, the experimental broadcasting station operated by John V. L. Hogan on 1550 kc. Phonograph record compensation and receiver critique are considered in these reports. Others are to follow

THIS report is to outline the problems met in connection with the design of high-fidelity receivers and to point out how these problems were solved in connection with receivers built primarily for listening tests of station W2XR but showing superior performance in connection with other local stations.

The five major requirements of a high fidelity receiving system are: one, uniform response throughout the audible frequency spectrum; two, low overall distortion generation; three, coverage of full dynamic range of transmitted modulations; four, low noise level in system; and five, proper acoustic characteristics in receiver and listening room. We shall consider these problems in order and their solution in the W2XR receivers.

As these receivers were intended for local reception, a three-coil tuned-radio-frequency circuit was chosen as being most suitable. An investigation of local conditions showed that practically all stations required a unique receiver fidelity for best results. The variation extended all the way from usable bare 5,000 cycle side-bands due to the presence of strong next channel interference and resulting "monkey-chatter" to full usable 15,000 cycle side-bands on station W2XR. To meet this requirement of variable fidelity without resorting to an additional adjustment, a switch tuning system was devised. A three-gang switch having as many points on each gang as stations to be selected was used. Each switch point was connected to an independently adjustable tuning condenser. Thus at any switch setting, the receiver was tuned by three independently adjustable condensers. With the switch set on position one, the three corresponding condensers were adjusted to give a 30,000 cycle band-pass at 1,550 kc for the reception of station W2XR. With the switch set on position two, the three condensers thus connected in the circuit were adjusted to give the best pass compatible with interference conditions of station WABC. This process was continued until a different station had been accommodated under optimum band-pass conditions at each switch setting. Thus whenever the switch was turned to a point corresponding to any particular station, that station was tuned in under optimum conditions. The tuning switch and a volume control are the only controls on the receiver.

Since there was found to be only a small variation in signal strength among local stations, a simple a.v.c. system consisting of biasing the first tube from the diode detector was used.

Distortion Sources

Since the response characteristics of the receiver were determined by the r-f selectivity, a flat response resistance-coupled audio amplifier was used. The speaker system responding over the range of from 30 to 15,000 cycles, consists of a high fidelity dynamic speaker covering the range from 30 to 5,000 cycles and a crystal "tweeter" extending the range up to 15,000 cycles. Each receiver was constructed with a large speaker baffle. Some were designed to fit into the corner of a room and others were built into a large cabinet. In the cabinet receivers the inside of the cabinet was treated with ozite to kill any resonance effects, thus giving a smooth bass response.

An investigation showed that by far the greater part of all harmonic distortion in radio receivers originates in the detector and output audio stages. Well designed receivers built along conventional lines generate a negligable amount of distortion in the remaining circuits. Diodes have long been known to be capable of low distortion detection. It was found that a diode having a large load resistor and operated with 2 to 10 volts input generate only 0.1 to 0.2 per cent harmonics. The W2XR receivers were designed to operate a diode detector within these limits. Push-pull, class A triode output tubes were used. When

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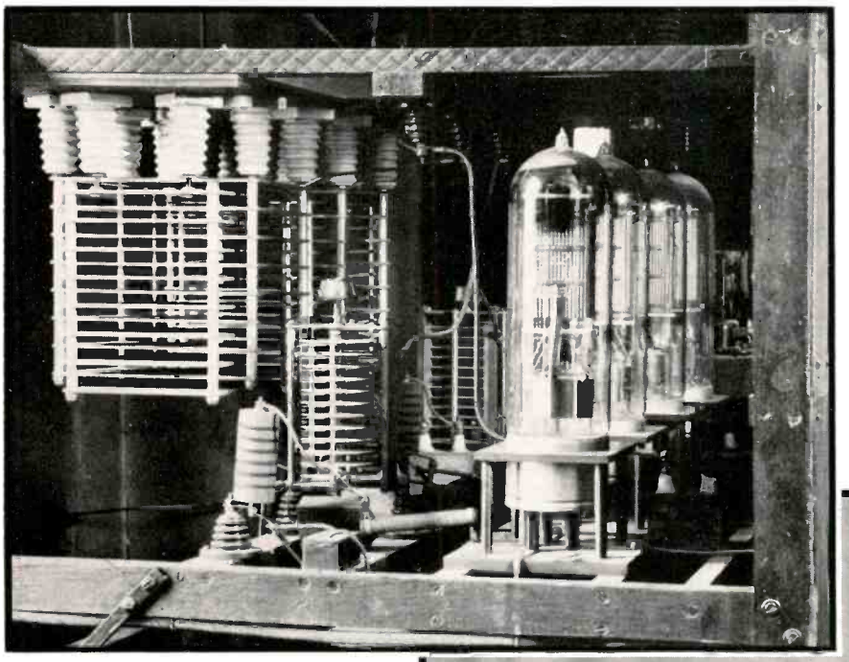
IN 1933 the Federal Communications Commission established three 20-kc channels in the region between 1500 and 1600 kc where broadcast stations, experimental in nature, could be located. Station W2XR Long Island City, New York, was one of the first of these stations. It has conducted many listener tests on volume and frequency range, and distortion appreciation, among others, from which much useful information has been obtained.

The reports published here are from those submitted to the FCC and are available to "Electronics'" readers through the courtesy of John V. L. Hogan, owner of W2XR and A. W. Barber, consulting engineer, under whose direction the work was carried out.



High-fidelity transmitter, W2XR showing novel fixed condenser at left

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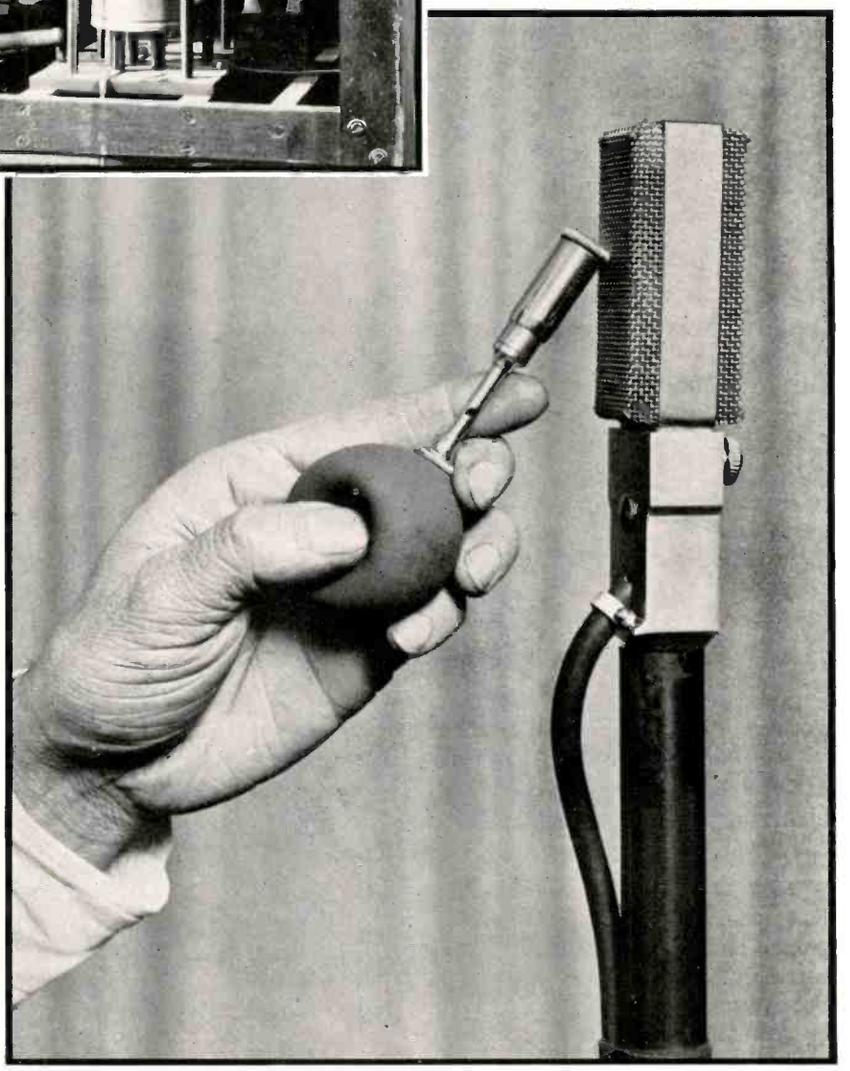
Galton whistle of variable pitch for testing high frequencies



operated at a fraction of their rated power output, the output stage produced very little distortion and it was found possible to keep the receiver overall harmonic distortion below 0.5 per cent. The push-pull voltage to operate the audio amplifier was supplied by the split diode circuit shown. The entire audio system was resistance-coupled except for the output transformer. This split diode circuit has the advantage over other circuits for generating push-pull voltages in that no transformer is used, and no phase inverting circuits depending on tube gain for balance are needed.

The dynamic range of a radio receiver is largely determined by the noise generated within the receiver and the available power output. Since these receivers were of the t-r-f type, the noise introduced was mainly of first tube origin. Close coupling between antenna and the first tube grid and high gain in the first tube minimized this noise. The use of adequate power output tubes kept the upper limit of the dynamic range high. It was found that man-made noises in New York City are much more troublesome to a wide band-pass receiver than to a normal receiver and necessitated the use of noise reducing antennas. Minimized lead-in pick-up coupled with efficient antenna pick-up proved to be a great help in reducing the noise. No accurate measurements were made but the noise reduction in many cases was apparently of the order of 20 db.

Listening room acoustics have received little attention in consideration of the important part they play in radio reception. Since it is standard practice to broadcast from studios treated to simulate ideal music room conditions, the listening room should be a relatively "dead" room. Also since speaker systems are always more or less directional they should not be pointed at highly

reflecting surfaces. The most satisfactory results are obtained under these conditions and when listening directly in front of the speakers.

SUMMARY: A high fidelity receiver has been described incorporating several design innovations. To provide automatically the optimum band-pass for each station received, a switch tuning system was developed. Each station channel includes a separately adjustable tuning system which after an initial adjustment, may be switched in, thus providing optimum and identical band-pass each time a station is switched in. In order to keep the number of controls at a minimum, all the frequency pass characteristics of the receiver are determined in the radio frequency tuning system, the remainder of the receiver having a flat response from 30 to 15,000 cycles. Low harmonic distortion was attained by the use of adequate class A, push-pull, triode output tubes and a diode detector operating within predetermined limits. Push-pull exciting voltage for the audio amplifier is generated by a split diode circuit thus eliminating transformers and phase inverting circuits. A wide dynamic range was attained by the use of noise reducing antennas, close antenna coupling and a high gain, first radio frequency amplifier stage. The best listening conditions were determined to be provided by listening directly in front of the speaker system in a rather "dead" room. The elimination of cabinet resonance was found to add to the pleasing rendition of bass notes.

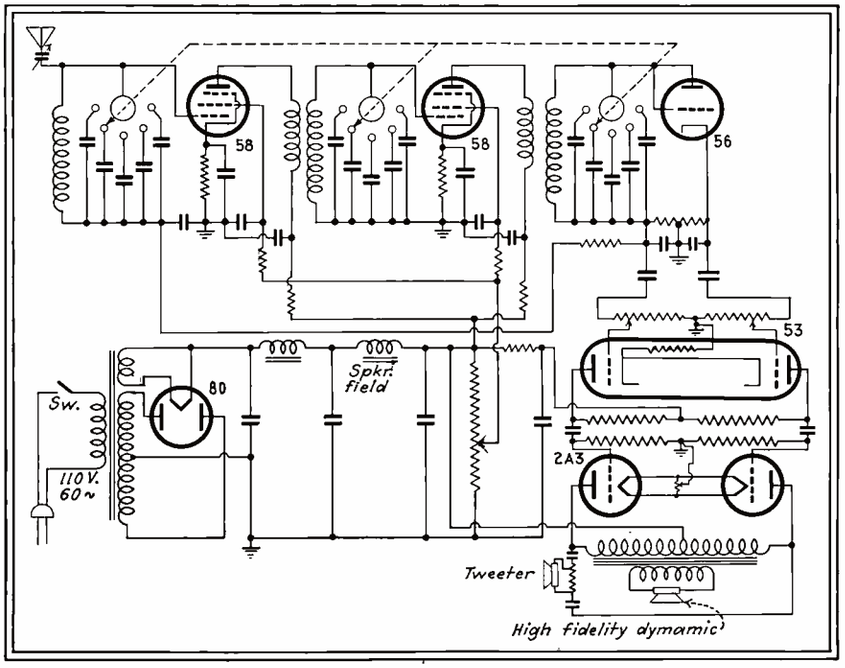
Extending the Useful Range of Recordings

EXPERIMENTAL broadcasting station W2XR has used a unique and very effective system for transmitting standard 78 r.p.m. phonograph records. Critics and laymen alike have been greatly impressed with the reproduction obtained without knowing anything of the story behind these transmissions.

Commercial phonograph records are cut, for the most part, at constant velocity from about 250 cycles up and at constant amplitude below 250 cycles. This means that theoretically a pick-up having a flat frequency response combined with a compensating circuit having a rising characteristic proportional to decrease in frequency below 250 cycles would give faithful reproduction of the original music on the record. Such a pick-up and compensating circuit was tried at W2XR but it was felt after some trials that a fixed compensation was not entirely satisfactory. The compensation system was redesigned and made variable from zero effect to something more than is generally needed. This variable compensation has been found to be very useful since its intelligent use permits corrections in recordings not possible with a fixed circuit. It has been found useful to be able to decrease the amount of compensation for some records where there seems to be an over emphasis of bass in the recording and also in the case of some records where there is a tendency to "wow," apparently due to recording turntable speed variations. On the other hand many records are materially improved by over compensation in the bass.

At the high frequency end of the spectrum tests showed that practically all pick-ups have a decreasing response especially above 5,000 cycles. While the crystal types of pick-ups were found to be definitely superior to magnetic types tried, they too did not maintain a flat response to 7,000 or 8,000 cycles which was considered desirable due to recent improvements in recordings. Hence it was decided to compensate the high frequencies by giving them a rising characteristic starting at about 3,500 cycles and increasing to a maximum at 7,000 cycles. Again variations in recordings showed a variable compensation desirable. Actually it has been found that many recordings are materially enhanced by a considerable increase in high frequency gain. This suggests that the recordings are often made with equipment having a falling high frequency response.

The circuit of the compensating amplifier finally adopted at W2XR is shown. The action of the circuits is based on varying load impedances in the plate circuit of a high impedance pentode V_1. The high frequency gain circuit consists of L_1 tuned to 7,000 cycles by C_1 and shunted by the compensation control resistor R_1. The low frequency circuit consists of inductance L_2 tuned to 80 cycles by condenser C_2 and shunted by the control resistor R_2. In series with these two compensating circuits is the gain control resistor R which determines the gain for the middle range of frequencies from 250 to 3,500 cycles and at the same time the ratio of obtainable relative compensation. Occasionally a record is found having a low



High-fidelity receiver circuit designed by A. W. Barber and used for testing the radio output of W2XR

recording level and a high scratch level and for such records a high frequency lossing circuit L_2, C_3, R_3 is used in the cathode circuit of V_1. This lossing circuit starts to attenuate at about 3,500 cycles and has a maximum effect at 7,000 cycles. Tube V_2 is resistance coupled to the output of V_1 and serves as a line coupling tube since it is not possible to couple a low impedance to V_1 directly without upsetting its frequency response characteristics.

By the use of the four controls described above an extremely wide and flexible range of compensation may be obtained. Curves a, b, c and d show four possible low frequency characteristics; curves e, f, g and h show four possible high frequency characteristics; and i, j, k and l show four middle frequency gain characteristics; curve m shows high frequency loss as applied to curve l. To get the actual combined frequency characteristic of the system various curves should be added as for instance a plus k plus g giving a large low frequency rise and a smaller high frequency rise.

Effect of Resonant Circuits

In addition to the flexibility of this compensating system, it has another very important characteristic and one which is often neglected in such circuits. It is well known that when a slightly damped resonant circuit is "shocked" by an electrical impulse, a transient oscillation is set up. This transient oscillation has a natural frequency equal to the resonant frequency of the circuit and the duration of the oscillation is greater the less the circuit damping. If such an oscillatory system is used in amplifying phonograph record reproduction, serious distortion always results. Many of these shocks exist in the music and scratch, which is a series of impulses, is always present. When low frequency compensating circuits oscillate, an unnatural prolongation of bass notes as well as other unpleasant effects are produced. If oscillation is produced in the high frequency compensating circuits, a hangover of the high tones results and needle scratch is heard as a ringing sound.

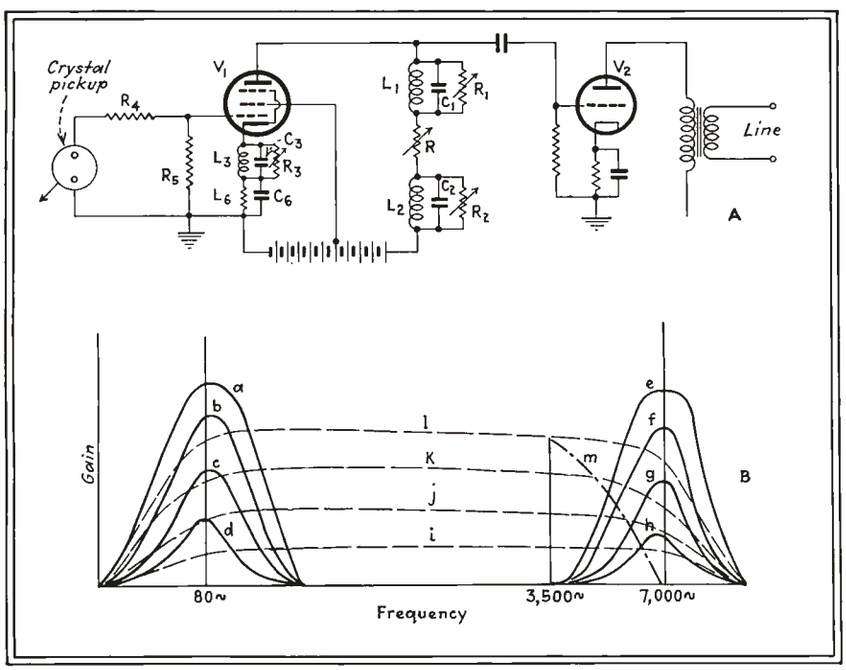
If compensating circuits have damping such that they are at least critically damped, these oscillations will not take place. Compensating circuits when critically damped give smooth, faithful rendition of music and at the same time alter the frequency response in any desired manner. All such circuits in the W2XR phonograph record reproducing system have shunts which are so designed that they cannot be made to produce less than critical damping. In the circuit the high frequency compensating circuit L, C has a shunting resistor R which may be varied from zero up to a value ($R = \sqrt{L/4C}$) which gives critical damping. Thus, even with large compensating effects, no extraneous oscillations can be set up in this circuit. The actual values used are $L_1 = 2.0$ h., $C_1 = 250\mu\mu f$ and $R_1 = 0$ to 40,000 ohms. The low frequency compensating and high frequency lossing circuits are similarly limited to critical damping. The success of these circuits in over a year of actual operation gives ample confirmation of the conviction that this non-oscillatory requirement is an important improvement in compensation circuit technique.

Aside from the above design considerations the system was carefully designed to prevent overload. The output of crystal pick-ups runs up to several volts on peaks and it was necessary to use the fixed attenuator consisting of resistors R_4 and R_5 in the grid circuit of V_1 to keep these peaks from exceeding the cathode bias of 3 volts.

Needle Selection

Another important point which sometimes is overlooked in phonograph record reproduction is the selection of needles. A wide variation in frequency response was found between different types of needles. After frequency response measurements using a wide range of needles, full-tone needles were selected and to insure uniform results, "shadow-graph" tested needles are always used in the transmissions from W2XR.

CONCLUSIONS: a flexible and effective system has been described giving very complete control over frequency compensation as applied to the phonograph record reproducing and transmitting system used by station W2XR. Both the high and low frequency ends of the audible spectrum may be independently raised any practical desired amount with respect to the middle register and the high frequencies may also be attenuated when necessary. By careful design considerations the compensating circuits are prevented from introducing undesired transients. The proper selection of needles and the prevention of overload also contribute to the excellent results obtained.



Compensating circuit for use when transmitting phonograph records; degrees of compensation effected

Television Scanning—A Survey

In which is disclosed the fact that variable-velocity scanning is not so new an idea as one might think, in fact dating back to days before the word "television" had been coined

By ROBERT F. DAVIS
Patent Attorney, Washington, D. C.

IN the last few years a number of patents have issued upon variations of a system of television scanning basically different from the one heretofore in common use. About 1929, a German, Rudolph Thun, in considering methods of television scanning, struck upon a new method which appears both novel and promising of better results than have been heretofore attainable. The advantages claimed for the new method include increased brilliancy of the image, better detail, and even simplification of the signal transmission. Whether all of these advantages will actually result is yet to be seen, but certainly there is reason to believe that at least some of them may be inherent in the new system.

According to the common methods of scanning, a beam of light is directed upon a scene, which may be either actual or a photograph, and moved about in a fixed path to illuminate successively all parts of the field. Thus the beam may move in a series of horizontal lines, a series of vertical lines, a spiral, or in any other configuration which will cover successively all parts of the scene. As the beam plays upon the scene, a photocell responds with electrical impulses to the amount of light reflected, the responses varying in intensity as does the shade of the part of the scene being scanned.

The movement of the beams at the sending and receiving stations being synchronized, it is only necessary to modulate the intensity of the receiver beam in accordance with the amount of light reflected from the portion of the scene upon which the sender beam is focused. Thus by the systems now in common use is the image formed on the receiving screen.

While simple in theory, great difficulties have been encountered in the practical application of this method of image transmission. One of the first difficulties is in obtaining sufficient intensity of light to illuminate the receiving screen. Since the effect of a small beam must be spread over the entire screen rapidly enough to make the whole screen appear illuminated, it is at once apparent that the beam itself must have an intensity many times that of the intensity apparent on the fluorescent screen.

Having provided such a beam the next problem is to vary its intensity in accordance with the incoming signal. Since the beam must have a high intensity there is necessarily a very high temperature at its source and this temperature must be varied as rapidly as the shades change under the rapidly moving beam of the sending scanner. To overcome these handicaps sufficiently to produce satisfactory large pictures has heretofore been practically impossible.

Considering the basic factors involved in scanning we note there are

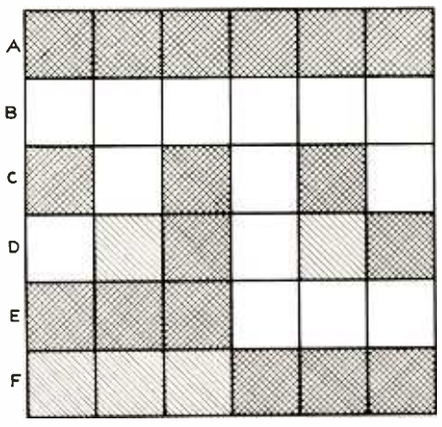


Fig. 1—Screen with three degrees of shade to be transmitted

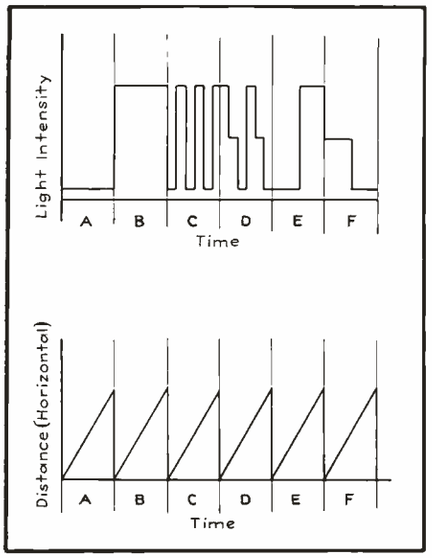
three: time, distance (of movement of scanning beam) and light intensity. The time and distance combine to give us the rate of scanning, which is usually constant for any single reception. The variable factor is the light intensity.

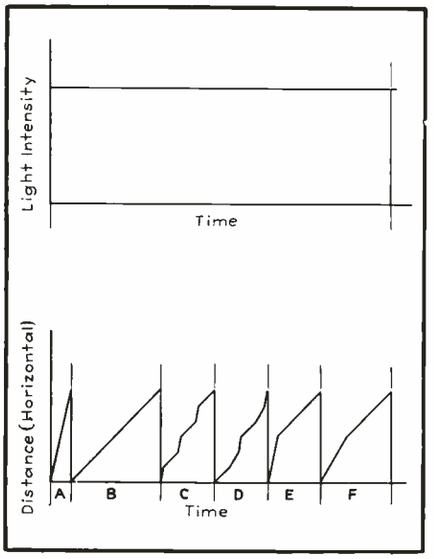
Apparently from some such consideration it occurred to Herr Thun that many practical troubles might be avoided if the rate of scanning could be made the variable instead of the light intensity. Since the eye or a photographic film normally integrates time with intensity in responding to a light stimulus it is apparent that if the scanning beam at the receiver be moved more rapidly over one portion of the screen than over another the portion covered more rapidly will appear darker. Thus by proper modulation of the scanning speed in accordance with the shade of the part of the screen being scanned Thun found it possible to produce images without varying the intensity of the light beam.

The Concept of Variable-Velocity Scanning

The theory of this method of scanning may be illustrated by the following figures which are partially similar to those in Thun's British Patent 355,319, August 17, 1931. In Fig. 1, a screen is shown having thirty-six squares, light, medium and dark in shade. Fig. 2 shows the relation of light intensity to time for one movement of the beam over this screen in the commonly used system. According to this figure the beam, starting at the upper left corner, covers the screen in six horizontal strokes at a uniform speed.

Throughout section A, which represents the time necessary for the first crossing of the screen, the light intensity is at a minimum because the screen scanned is dark. In the section designated B, however, the light intensity is at a maximum because the screen being scanned is light. In section C the light intensity alternates between the minimum and the maximum as does the shade of the scene. In section D an intermediate shade is introduced to which the beam intensity responds





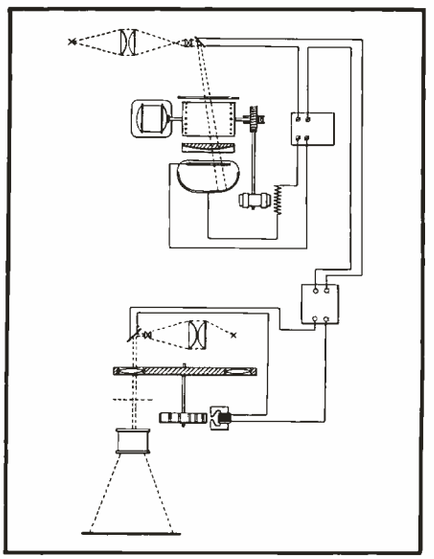


Fig. 2, left—Relation between light intensity to scanning time for Fig. 1 and saw-tooth scanning beam amplitude as it moves across Fig. 1. Fig. 3, center—Light intensity in variable-velocity scanning; relation of beam movement to time. Fig. 4, right—Thun's apparatus, British Patent 355,319

with approximately one-half its maximum strength. The same correspondence is evident between the succeeding sections.

During this scanning, as shown in Fig. 2, the beam moves across the screen at an even rate and then falls back only to repeat the cycle. To transmit the image, the information represented above and below in Fig. 2 must be sent, the former governing the light intensity and the latter functioning to synchronize the transmitter and receiver beams.

Under the new system the charts show very different characteristics. Since the light intensity does not vary, Fig. 3, in which light intensity is plotted against time, is merely a horizontal line the exact height of which is not of great importance and the information in this figure need not even be transmitted.

In Fig. 3 showing the relation of the beam movement to time according to the new system we find a vast difference from Fig. 2 showing the same relation in the old system. Section A is very short, section B very long and the following sections have irregular lines showing numerous changes in the rate of scanning. A closer inspection shows that little time is spent on the dark areas such as section A but that a much greater time is spent on the light areas than was possible in the old system. Compare the time represented by Section B in Fig. 2 with the time represented by the same section in Fig. 3. Although the relative distances on the charts represent no concrete example they clearly illustrate the theory.

Under such a system more apparent light intensity and greater detail seem likely to result from the slower scanning of the light areas and the more intense light source which may be used if intensity modulation is avoided. Dark backgrounds will give the beam even more time for the light areas and it should be possible to greatly increase both the intensity and detail of the center of attention by their use.

Thus far we have proceeded in theory, but a mention of the apparatus which has been used, without going into great detail, will serve to give a practical aspect to the new method. The mechanical means used by Thun to perform his scanning consist of a motor-driven feed for a film on which is recorded the picture to be transmitted, an electrically-oscillated mirror fixed to reflect a beam of light back and forth across the film and a photocell arranged to receive the light passing through the film and modulate the speed of the mirror's oscillation accordingly. The same photocell also modulates the speed of a similar oscillating mirror at the receiver, thus forming a facsimile of the original picture by light reflected from that mirror onto a receiving film.

In addition, the photocell wave at the transmitter is superimposed on a wave formed by a generator connected to the feeding device so that the resultant wave can be used not only to operate the oscillating mirror at the receiving station, but also

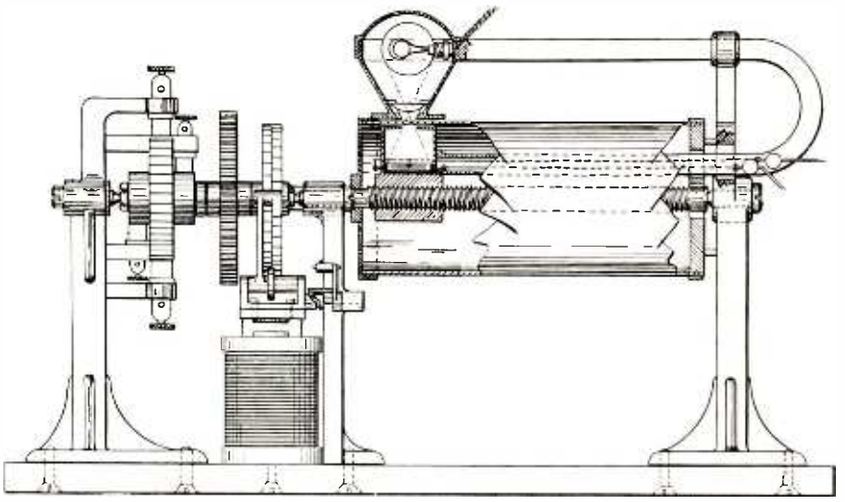


Fig. 5—Variable-velocity device of Sellers, U. S. Patent 939,339

to operate a synchronous feeding motor for longitudinally feeding the film upon which the picture is received. As will be apparent, the new theory is here applied only to the lateral scanning and not to the longitudinal movement of the film. A diagrammatic sketch of Thun's apparatus as illustrated in his British Patent 355,319 is given on page 31.

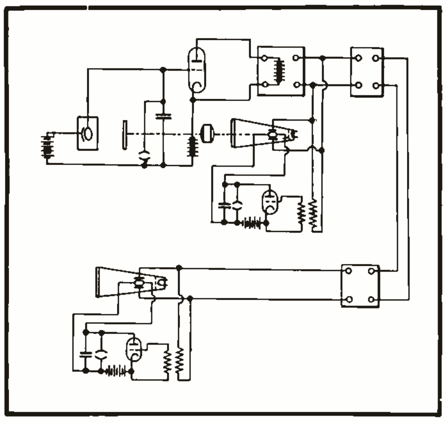


Fig. 6—More recent Thun patent showing cathode-ray tube

In a later patent (British 377,175, July 19, 1932), Thun discloses a more intricate device for the same purpose and also a cathode-ray scanner or Braun tube. This device purports to apply the new theory to both the horizontal and the vertical scanning.

A probable difficulty with this circuit lies in the vertical scanning which is accomplished by a discharge tube-triode tube combination operated from the horizontal scanning circuit. Each horizontal scanning movement actuates the triode to partly load the discharge tube. When a sufficient number of partial loadings have been made the voltage becomes great enough to discharge the tube. It seems to the author that this part of the apparatus may be inoperative because the discharge tube cannot be adjusted to give the exactly correct number of lines of horizontal scanning to each picture. If this is so it will be difficult if not impossible to "frame" the picture. A major difficulty is probably also inherent in Thun's oscillating mirror construction because the inertia of moving parts will prevent sufficiently rapid response.

Other information on the work of Rudolph Thun on this subject may be obtained from a magazine article "Helligkeitsteuerung und Liniensteuerung," pages 161 to 167 of the July, 1931, issue of *Fernsehen*, available at the United States Patent Office Library. Thun has obtained French Patent 695,622 and several others besides those already mentioned.

Another recent inventor, Manfred von Ardenne, has obtained British Patent 383,880 for a cathode-ray scanning device operating on the same general principle. The contribution of von Ardenne consists in a device in which the rate of scanning is the same at all times except for the modifications introduced by the light-intensity factor. In other words, von Ardenne eliminates the variation due to circuit characteristics. This he does by connecting an additional Braun tube in parallel with the tube in use and adjusting the added tube and its operation so that it acts as a ballast resistor across the plates of the main tube.

In a study of patents on devices of this nature it is interesting to note that although there are very few patents thereon and nearly all of these relatively recent, a device embodying the general principle was patented in the United States long before the word "television" was familiar and indeed even before "radio" became popular. True, the device was not designed for projecting pictures rapidly enough to form visual images but the essential idea is present as will be evident. The situation serves to illustrate how many of our inventions are antedated by relatively old patents disclosing broadly the inventive concept. This does not, however, preclude the obtaining of valid patents on improvements which make the devices commercially useful or successful.

On November 9, 1909, the United States Patent Office granted to Gilbert Sellers of Chicago, Ill., a patent on a device for electrically transmitting messages. Fig. 5 is a reproduction of Fig. 1 of this patent.

The device consists of a rotatable transparent cylinder upon which a message or photograph is placed. A selenium cell within the cylinder and a light source outside are moved in an axial direction by a threaded shaft as the cylinder rotates. An electric motor rotating the cylinder and controlled in speed by the selenium cell completes the apparatus. When transparent portions are being scanned and the selenium cell is illuminated the motor operates rapidly and as dark or opaque areas are scanned the speed is lessened. The receiver operates in synchronism and using a photograph film receives a negative of the image. Since this patent expired in 1926 the broad principle and all else described therein is now open to public use.

Volume Expansion

[*Continued from page 16*]

range than any other radio or phonograph which has been manufactured to date. To realize the greatest amount of benefit from the expander, the recording technique should be investigated with the idea of possibly incorporating some form of automatic compression. This compression would serve to hold the dynamic range during recording to within the required 45 db. An expander having a curve the reciprocal of the compressor could easily be made, and the result to the ear would be very close to the original. It is doubtful whether such a compressor device would in any way result in an inferior recording when played on a standard phonograph. On the contrary, if the compressor were properly designed, there is every reason to believe the result would be more pleasing, because the monitoring would be smoother, and there would be no danger of over-cutting on the highest levels. When reproduced on a phonograph having an expander of the proper type, the resulting reproduction, as far as dynamic range is concerned, would be exactly the same as the original.

The expander described in this acticle is of course not limited to record reproduction, but with minor changes can be adapted to radio. To use the expander on radio, certain precautions will be necessary such as: keeping the signal on No. 1 grid below 1.5 volts, properly adjusting the gain of the rectifier amplifier, and making provision for cutting the expander out on voice. On the whole, however, the overall result would be fully as pleasing as on record reproduction.

NETWORK RESISTANCES

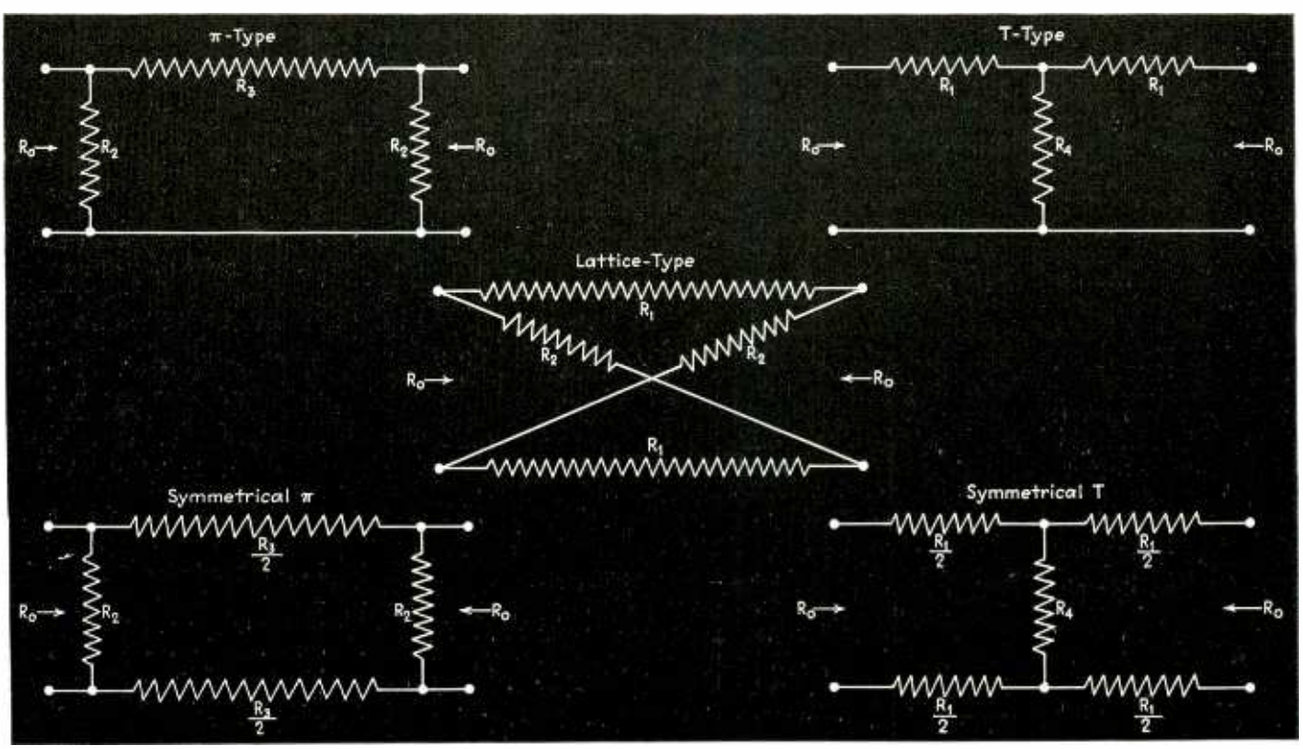
For Balanced Attenuators

By R. E. BLAKEY

THE ATTENUATOR SECTIONS shown below contain resistance elements whose values for any desired degree of attenuation can be calulated by reference to the table at the right. Multiply the desired characteristic resistance R_0 (resistance looking into either end of the section) by the factor appearing in column "1" opposite the desired attenuation to obtain the value of resistance R_1. Similarly multiply R_0 by the factor in Column "2" to obtain the value of R_2, by the factor in Column "3" for R_3, and by the factor in Column "4" for R_4. These values of R_1, R_2, R_3, and R_4 are the required resistance values to use wherever indicated in the diagrams below, to obtain an attenuator section having the desired attenuation and characteristic resistance.

ATTENUATION DESIRED IN DECIBELS	MULTIPLYING FACTORS × R_0			
	"1"	"2"	"3"	"4"
0.25	.01470	68.03	.02955	33.85
0.5	.02874	34.79	.05761	17.361
1.0	.0575	17.39	.1153	8.669
2.0	.1146	8.726	.2323	4.305
3.0	.1710	5.848	.3524	2.838
4.0	.2260	4.425	.4776	2.094
5.0	.2802	3.569	.6080	1.645
6.0	.3325	3.007	.7469	1.339
7.0	.3824	2.614	.8961	1.116
8.0	.4305	2.323	1.0575	.9452
9.0	.4760	2.101	1.2316	.8117
10.0	.5194	1.925	1.4229	.7028
15.0	.6980	1.432	2.720	.3675
20.0	.8183	1.222	4.95	.2020
25.0	.8940	1.119	8.876	.1127
30.0	.9389	1.065	15.8	.06332
35.0	.9651	1.036	28.131	.03555
40.0	.9804	1.020	50.00	.0200

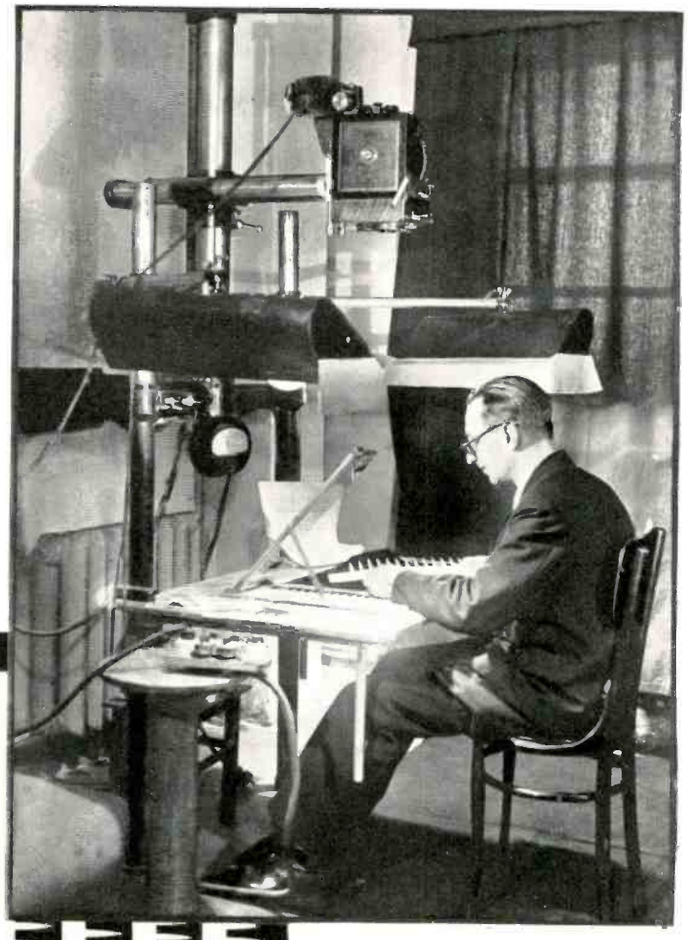
"1" = tanh — db/(2 × 8.69) "2" = coth — db/(2 × 8.69)
"3" = sinh — db/8.69 "4" = 1 ÷ "3"

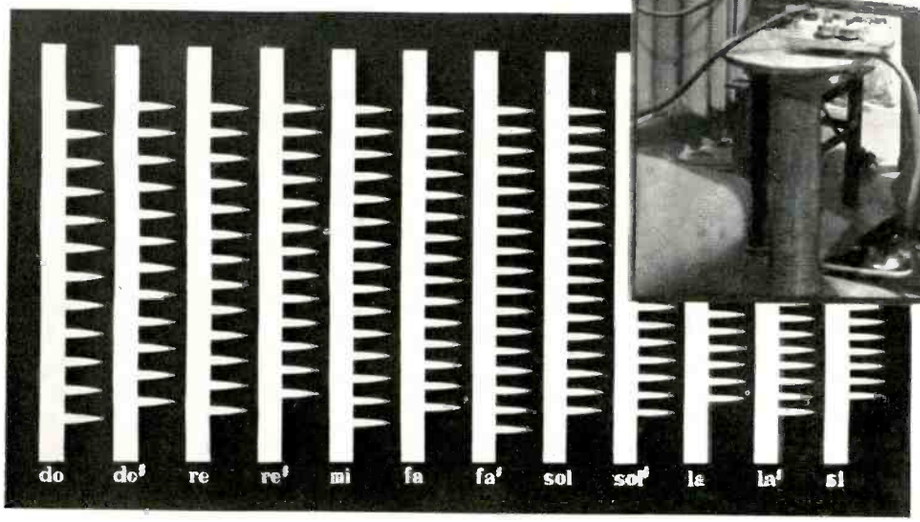


ELECTRONICS REFERENCE SHEET

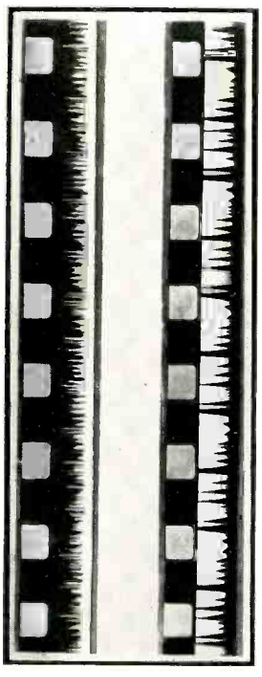
HAND-DRAWN SOUND

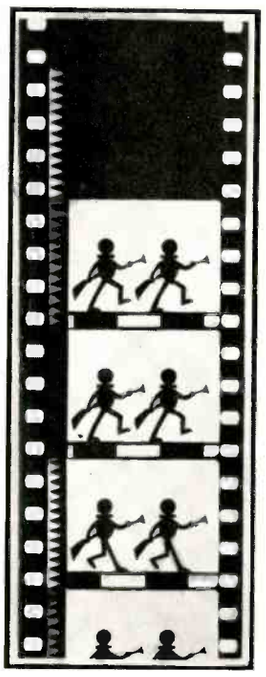
Synthetic sound tracks, the latest manifestation of the scientific Spirit in Russia

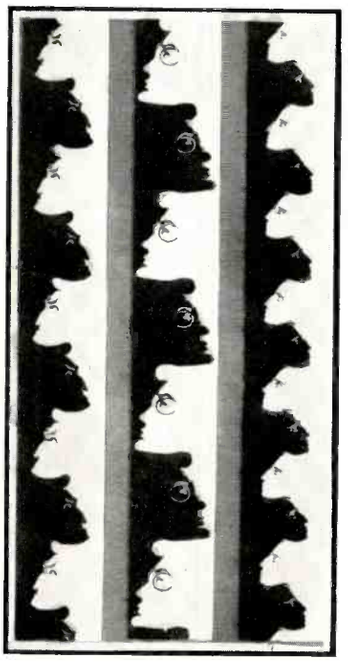




Above, N. Vionov, animated cartoonist of Moscow, at his work of producing "comb" sound tracks. At the left are several samples corresponding to the notes of the chromatic scale



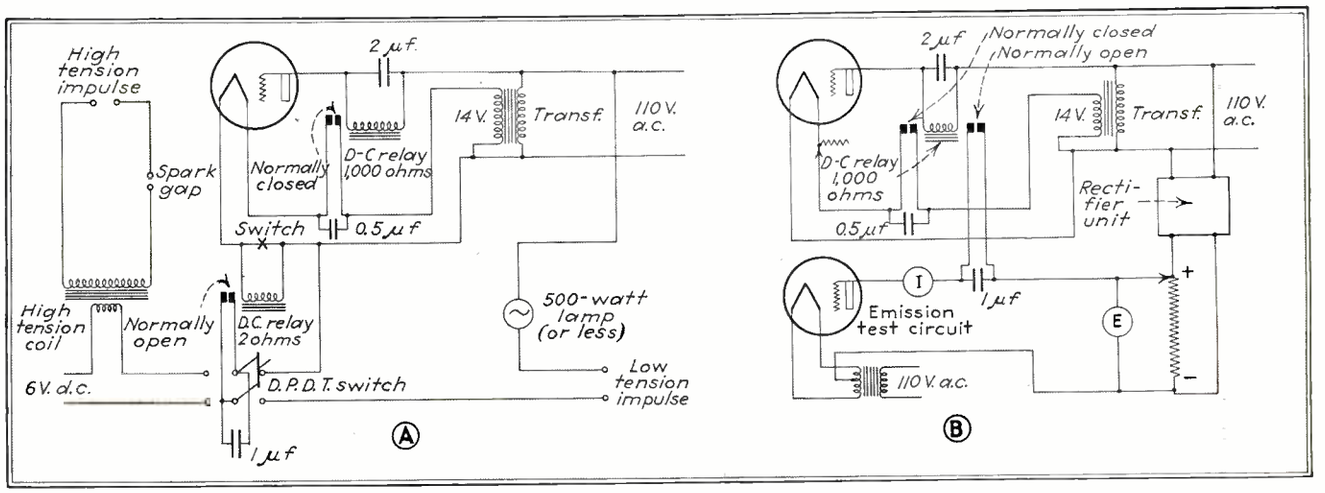




Left: Comparison between natural (at left) and artificial sound tracks. Both represent the chord do-mi-sol played on the piano

Center: "The March of the Chessmen," a cartoon with artificial sound accompaniment, shown in the track at the left

Right: "Technical fantasy." Profiles of the two inventors of the system and their assistant. The result, when run through a sound projector, "approached" the timbresky of a violincellosky



Two applications of the electronic interrupter. (A) is an arrangement for producing high tension voltage impulses for cable testing, while (B) is an emission tester

An Electronic Interrupter

A simple device for controlling an intermittent relay circuit by means of a diode-connected filament-type triode. Current interruptions of controlled period thus produced may be used for a variety of laboratory and industrial purposes

By JAMES H. HANLY

ONE of the handiest instruments to have in a research laboratory is an interrupter, especially one which can be controlled over a fairly wide range of frequency. Whereas most mechanical interrupters which can be made to operate over wide ranges are not only expensive but are generally large in size, the electronic interrupter described here can be built at a very small cost and in a space 6 x 8 inches.

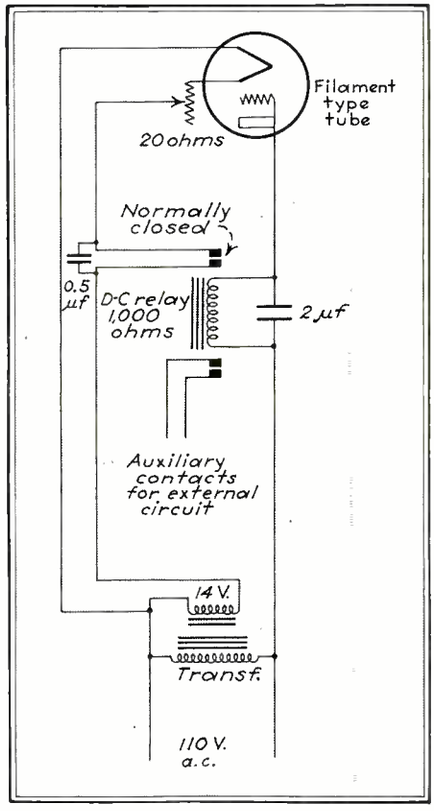
At the right is shown the schematic diagram of the interrupter. The operation of this unit is very simple. The plate current of the tube flows through the relay coil, causing the two contacts to open. When these contacts are opened, the current to the filament is cut off, and the plate current is interrupted. After the demagnetizing of the relay coil, the contacts are closed again; this energizes the tube filament once more, thus repeating the sequence of operation.

It will be noticed that the filament circuit is energized by a 14-volt supply fed through a 20-ohm rheostat. The reason for this relatively high voltage is to give a high velocity operation to the emitter in the tube. The rheostat gives a fairly complete control of the velocity of operation.

As can be seen from the diagram, the output of the tube to the relay coil is of a half wave nature. For this reason a relay with a shading coil or one shunted by a condenser is needed. The latter type is used by the writer. The condenser discharges through the relay coil when the tube is going through its inverse operation, thus keeping the armature from chattering. A small fixed condenser across the filament-break contacts cuts down the wear from pitting; a half-microfarad was found sufficient. The auxiliary contacts on the relay can be used to open or close any external circuit.

Type of tube used

Any type of vacuum tube, ranging from the 201 A to the 281, which has a filament-type cathode, can be used. The first type gives impulses in the order of 3 per second at full voltage, while the latter will give impulses in the order of 1 every 3



Circuit of the interrupter. Thermal inertia controls the frequency

seconds and can be varied to about 1 every 15 or 20 seconds, depending upon the current flowing in the emitter circuit. The use of indirectly heated cathode tubes is not advised, unless they are operated at rated heater voltage, as they will be ruined before the first cycle of operation is completed.

In the operating cycle diagram on page 35, it will be noticed that after the relay has opened the filament circuit there is slight rise in the emission, momentarily. This is due to the current overswing which occurs just as the contacts break. The length of time that the filament current is off depends upon the tube used. The 201 A, 171 A and the 210 type tubes, being low emission tubes, will have a much shorter filament-off period than the 245 and 281 tubes, which are high emission tubes.

When the grid and plate are tied together, large electron emissions, enough to operate the relay, are produced before the tube reaches its rated filament current. Thus the tube cuts itself clear before damage can be done.

Life tests on tubes show that from 600 to 1,000 hours of operation can be obtained on the tubes mentioned, with the exception of the 201 A. This ran near 200 hours.

Use in a Cable Tester

Recently the writer was given the task of developing a unit to test an underground cable which had shorted between phases as well as going to ground. In all types of cable testing it is desirable to have an impulse current flow to and from the defect. Here the electronic interrupter becomes the basic instrument in the tester. On page 35 is shown the schematic diagram of the cable tester developed and used successfully.

It will be noted that another relay was added to the circuit. This relay is a 2 ohm d-c unit. The reason a d-c relay was used in this a-c circuit was to make it operate as a vibrator. The vibrator action causes its contacts to rapidly make and break the primary current to the induction coil for the high-tension impulse and the current to the lamp for the low-tension impulse. The 1 μf. condenser across the contacts serves to cut down the burning at the points and gives the impact necessary to the proper operation of the induction coil. In the high-tension circuit a spark gap was inserted so that when the high voltage was fed into a short circuit there would not be a bad drop in the voltage output of the induction coil.

Use in a Tube Emission Test

It is well known that in emission tests of vacuum tubes where the plate and grid of the tube are connected together it is dangerous to operate the plate and filament at their rated voltage for a long period of time. Here the application of the electronic interrupter makes complete emission tests possible without danger to the life of the tube.

On page 35 is the circuit diagram of the electronic interrupter connected to the emission test. With a 281 in the interrupter socket, the speed of the interrupter can be cut down so that the current-on periods in the emission test are just long enough to take the necessary readings. It might be well to note here that a highly damped meter is necessary in the plate circuit of the emission test when the interrupter is used.

Armstrong System

[*Continued from page 19*]

This analysis proceeds from the assumption that the carrier is stronger than the noise. In quiet locations (no ignition interference), shot noise and thermal agitation become the limiting factors. Discrimination against this type of noise has been carefully measured; under comparable conditions, a f-m carrier on 41 Mc. with a 150 kc. band-width produced an energy of signal 1,100 times greater in relation to the noise than did a 7.5 kc. amplitude-modulated channel. Experiments with ignition interference were not so thorough or systematic, but it was found that the peaks of this transient type of noise are often comparable with the signal, and that the noise discrimination is then not nearly so effective. But with cars within 40 feet of the dipole antenna, complete suppression of the noise was achieved with a signal (generated locally) 10 times the field strength of the Empire State Signal.

At the demonstration given at the I. R. E. Meeting, frequency-modulated signals from W2AG a 100 watt station in Yonkers, N. Y. (about 20 miles away) were picked up with an f-m receiver installed near the speaker's platform. The transmitter, at the home of C. R. Runyon, on 2.5 meters (120 Mc.), had a frequency modulation band of 100 kc. Lantern slides showing the apparatus used at the transmitter were thrown on the screen before the audience at the same time that a description of the transmitter was being received from Yonkers. The result was a very convincing demonstration of the new system. The quality of reproduction was as good as that of the best broadcast stations, and the interference level, produced by a noise-infested city area, was very low.

In addition to this demonstration, a sound-film record of reception at the Haddonfield location was reproduced. It contained samples of reception from the f-m transmitter on the Empire State Building, and the broadcast station WEAF, operating on 660 kc. with 50 kw. and also with station WMCA, a station which draws about the same power from the supply mains as does the f-m transmitter. All the f-m transmissions were reproduced with only a trace of background noise, and with good quality, while the signals from WEAF were so marred by static from a thunderstorm within 20 miles of Haddonfield that only occasional words could be heard. The signals from WMCA were almost completely below the static and tube noises.

It was made clear by Major Armstrong that the paper is to be viewed primarily as revealing a new radio signalling system, by which frequency modulation over wide bands at short wavelengths makes possible a considerable reduction of noise from all sources. The apparatus and methods used are merely incidentals to attaining this end.—D. G. F.

The "Loop Test" tells the tale

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The "loop test" demonstrates that S. S. WHITE REMOTE CONTROL SHAFTS, expressly developed for auto radios, require little more effort to rotate them when they are curved than when they are straight and have no tendency to "jump".

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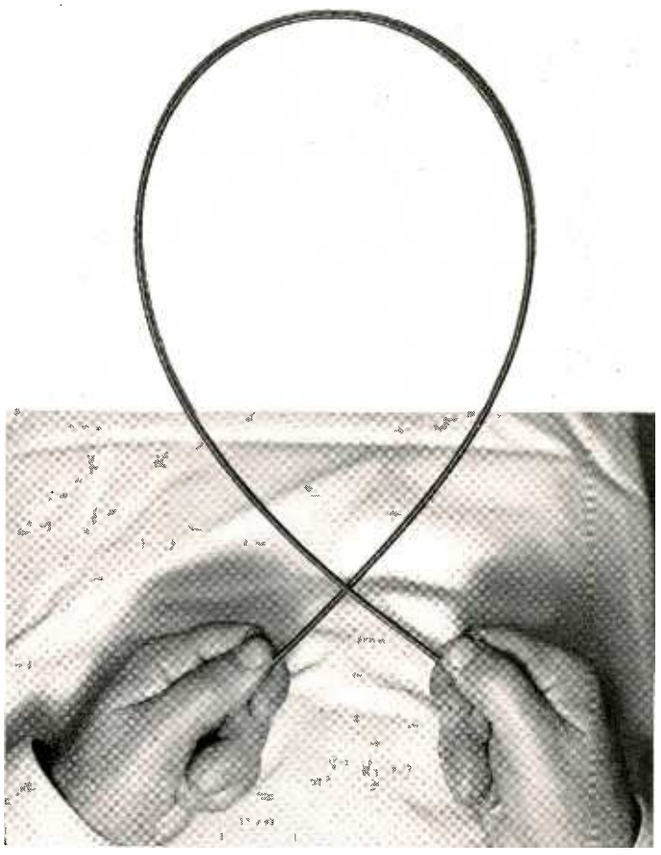

THE "LOOP TEST"

Take a 3-foot or longer length of shaft. Hold it at the ends as shown with the loop resting on desk or table. Then rotate it with the fingers in either direction.

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MOLDED RESISTORS from 1000 ohms to 1,000,000 megohms.
Details about any of these products supplied on request.

TUBES AT WORK

Phototube Timers for All New York Race Tracks

THE USE of high-speed motion pictures for timing horse races has been recommended by the New York State Racing Commission for all tracks in New York State, effective October 1. Although the device is not electronic in principle, its operation will be initiated by a phototube. At the beginning of the last eighth or sixteenth mile of the race the first horse to pass the phototube interrupts a light beam and thus starts the operation of the camera. It photographs all horses in the race continuously until the last has passed the finish line. Photographed on the same film with the pictures of the horses is a picture of a split-second timing device which records the finishing time of each horse in the race. The negative taken by the camera is developed in a minute and a half, and a print posted for public observation three minutes after the race is finished. The developing mechanism is attached to the camera itself.

The machine is operated by a crew of eight men, and will cost Racing Associations about $300 a day for each installation. The camera is mounted high above the judging stand, on top of the grandstand. The finishing time can be determined to within one hundredth of a second by the use of this device, and the pictures are of sufficient clarity to distinguish between the noses of horses which finish barely an inch apart, as was demonstrated recently in the Santa Anita track in California.

• • •

A.C. Bolometer Perfected by Professor Moon at M.I.T.

A MUCH SIMPLIFIED instrument for precise measurement of light has been developed in the electrical engineering department of the Massachusetts Institute of Technology by Prof. Parry H. Moon. The device is known as an alternating-current bolometer of great sensitivity; its intended use concerns research on the output of various forms of electric lamps. Previous instruments used for this purpose are the direct-current bolometer, invented in 1880; the thermocouple and photocell. All these devices have had serious drawbacks, particularly in sensitivity and accuracy of measurement.

The Moon bolometer resembles a radio tube in general appearance. Inside the tube is a small "target" made of blackened metal. When light falls on this target the heat rays of the light increase the temperature of the blackened surface, so that a slight change in the current flowing through the tube is produced. This slight change of current is amplified by means of an alternating-current amplifier. This eliminates the difficulties with high sensitivity galvonometers and eliminates the direct-current component which, with direct-current devices, confused the record of changing temperatures.

• • •

Sodium Gas Lamps Used on San Francisco Bridge

A TOTAL LIGHT OUTPUT of more than 8 million lumens will be provided by the sodium light installation for the New San Francisco-Oakland bridge. These lamps produce a very efficient yellow illumination by the passage of current through a sodium vapor. The new installation will contain 922 lamps, supplied in 25 circuits along the 15 miles of roadway in the bridge. The type of lamp used on the upper deck of the bridge for use with high-speed traffic provides 10,000 lumens each, while the lower deck will be provided with 6,000-lumen lamps.

In addition to the high efficiency of light production which results from the large proportion of visible light to other radiated energy, the installation is said to afford high visibility, freedom from glare and economy of operation. The equipment has been designed and manufactured by the General Electric Company.

• • •

Increased Accuracy of Naval Observatory Time Signals

THE NAVAL OBSERVATORY at Washington installed in September an automatic system for photographing the stars in the sky, for the purpose of increasing the precision of time determinations. As a result the accuracy of time signals broadcast by the Arlington radio station has been increased to within one one-thousandth of a second. The Arlington signals, which are used by jewelers all over the country as a

NEW YORK'S QUIETEST SPOT

Professor William H. Barton and Dr. Clyde Fisher measuring the noise level inside the new Hayden Planetarium, whose acoustic treatment gives it an unusually low noise level

time service, are now the most accurate time transmissions in the world.

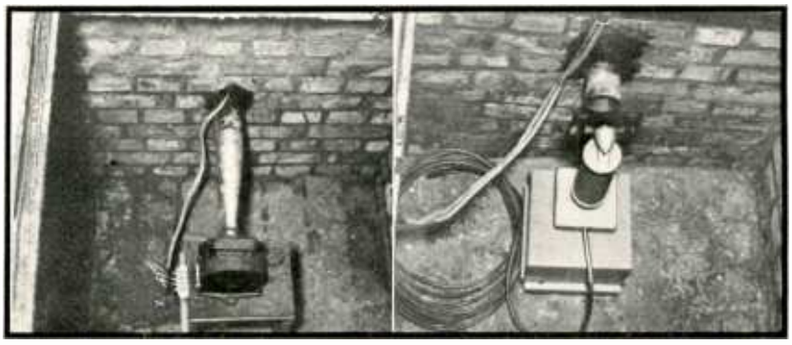
Checking the master clock from which the time signals are taken has been done by human observers using telescopes trained on certain stars. The human element thus introduced has caused small but definite variations in the time observations. The new automatic camera takes pictures of the sky at predetermined intervals. The prints from the camera are based on a calculating machine which indicates the time at which they were taken without the necessity of involved calculations. Corrections on the master clock are made once a day on the basis of these measurements.

• • •

Photo Alarm Calls Police on Telephone

AN AUTOMATIC photoelectric burglar alarm which turns in a spoken alarm to the police was described at the annual convention of the United States Independent Telephone Association by Henry Herig, of Short Hills, N. J. The photoelectric alarm makes use of infra-red light beam which is reflected by mirrors placed at strategic points. The interruption of the beam by the burglar actuates the photocell circuit. This circuit is connected to a relay system which automatically dials the police station. At the same time it sets in operation a phonograph which sends out the following message over the telephone line: "This is an emergency call. There are burglars in the house at 150 Main St." The message is repeated several times by the record.

A GERMAN ANTI-ECHO P. A. SYSTEM

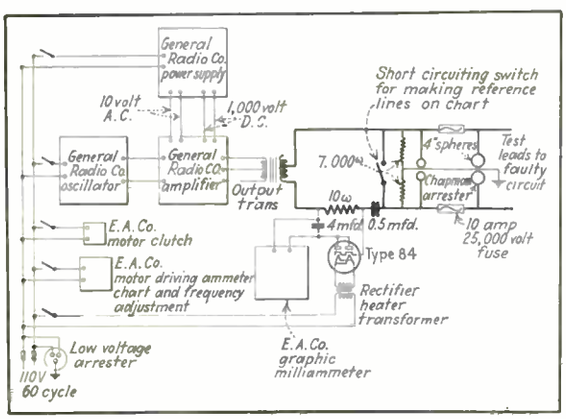


By running acoustic pipe lines underground between the main speaker and the auxiliary speakers in a large outdoor public address system, troublesome echoes have been eliminated. Above left is a speaker unit feeding into the pipe; at right the microphone pickup

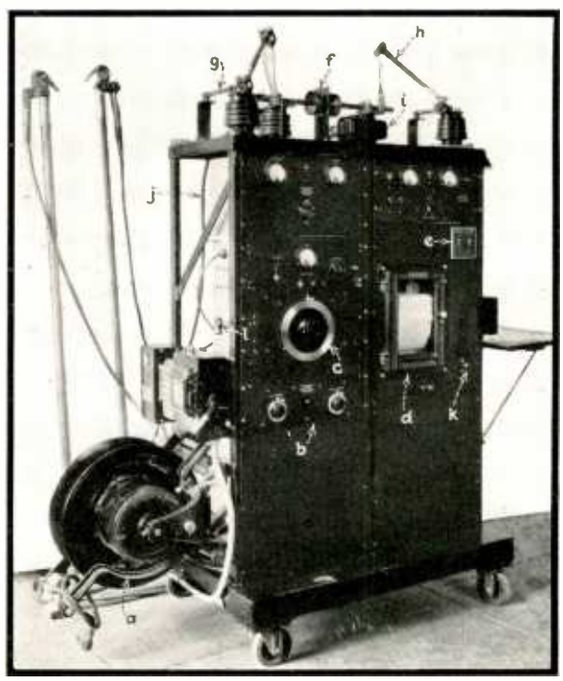
• • •

Oscillator Locates Faults in High-Tension Transmission Line

THE USE of a varying frequency a-c current to determine the location of grounds, open and short circuits in power transmission lines, has been made by the Pennsylvania Water & Power Co. An oscillator and amplifier capable of supplying frequencies from 1 to 100 kilocycles is connected to the faulty line and frequency increased while the current in the line is recorded on a graphic milliameter, which automatically records variations. It will be found that sharp current peaks occur at equally spaced intervals as the frequency is increased. The frequency interval is then a measure of the distance from the application of the voltage to the fault, expressed by the formula, $L = V + 2d$, where L = distance in miles, V = wave propagation in m.p.s. (determined for each circuit by test) and d = average difference in frequency between current peaks. By means of such measurements the accuracy of location in most cases can be made within 2 per cent. The cause of the current peaks is the reflection and phase shift which the alternating current undergoes at the fault in the line, the result being that certain frequencies are reinforced by the reflection, while certain others suffer destructive interference. In the apparatus used the entire oscillator-amplifier, power supply, and recording instruments are mounted on a portable truck containing all the necessary apparatus.



The apparatus shown at the right contains equipment for locating the position of faults in power transmission lines. The diagram of the apparatus shown above indicates the method by which a variable frequency e.m.f. is applied to the line. By noting the frequencies at which maximum and minimum current flows, the length of line to the fault may be determined



Seven New Ideas

in Bakelite Molded Radio Cabinets

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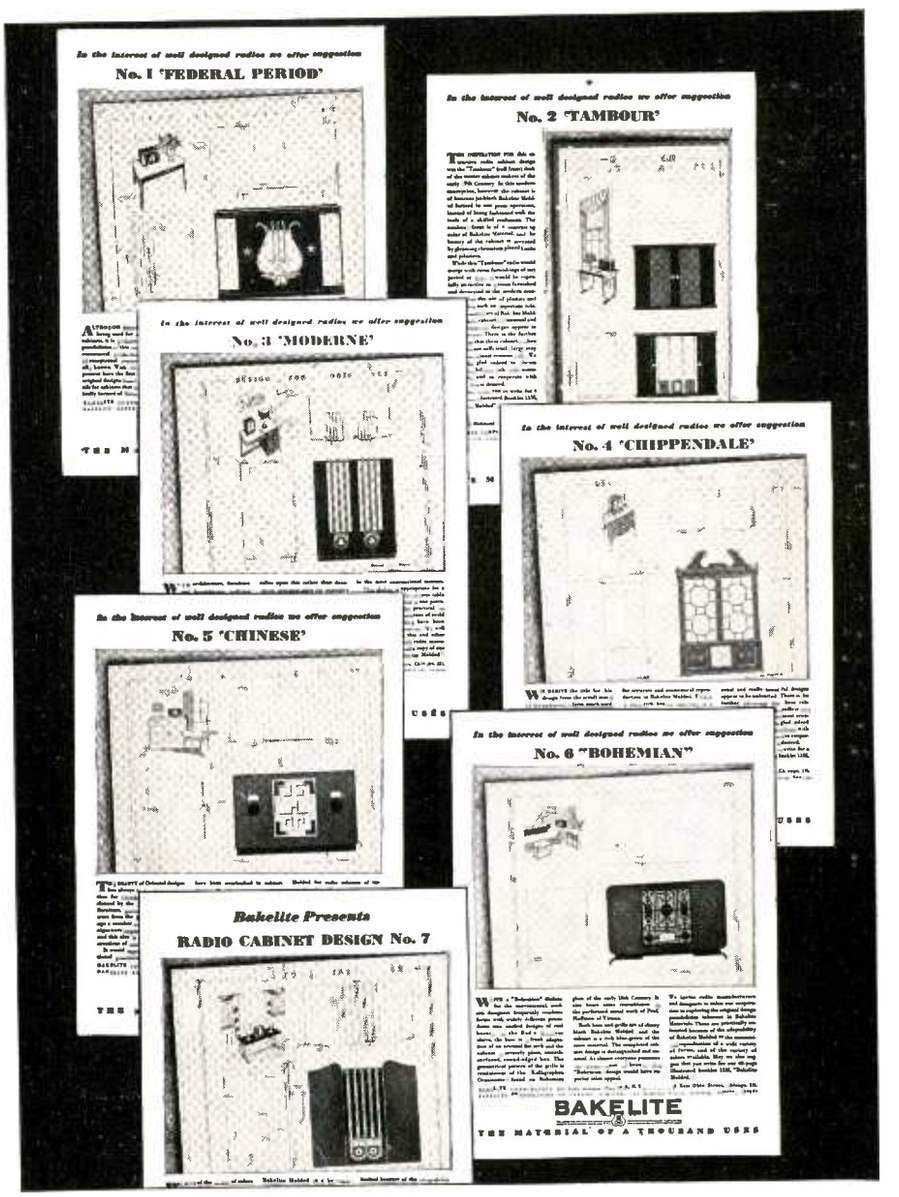
The benefits of our long experience in designing molded products are placed at the disposal of radio manufacturers. We will be glad to cooperate with you in putting into practice any of our "period" designs or your own original ideas. For your preliminary studies, send for our new Portfolio containing detailed information on our seven design suggestions.



Write for this Portfolio today! It contains descriptions and illustrations of seven original designs for radio cabinets which exemplify the new broad range of cabinet beauty now open to designers through use of lustrous, colorful Bakelite Molded. All designs were made with consideration for production economy and the practical requirements and limitations of molding.

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1910 — SILVER ANNIVERSARY — 1935

Views and Reviews

BOOKS for the shelves of engineers and technicians in the electronics field: *Modern Radio Servicing; Theory of Alternating Current Wave-Forms,* and *The Cathode-ray Tube at Work.*

Modern Radio Servicing

BY ALFRED A. GHIRARDI. *Radio & Technical Publishing Company, 1935. (1300 pages. Price $4.00.)*

THERE WAS A TIME when practically anyone could service a radio receiver. If it didn't "play" you whacked the detector tube and if a bong came out of the loud speaker you felt sure the audio amplifier was not in trouble. Then you took the antenna wire and put it successively on the grid of the detector, the first and second r-f tubes until you had found which was the dead stage.

This was before Trube, Ballantine, Wheeler, Jarvis, Travis et al, including those at Camden got busy with perfectly good radios and put a.v.c., intercarrier noise suppression, diode detection, variable-mu tubes and other tricks into everybody's set. Furthermore they were unsatisfied with a straightforward (from the standpoint of service) t.r.f. job and made nearly everyone own a much more complicated superhet. Then someone got the all-wave idea, and now they are to have wide-band receivers.

The result is that practically no one can service a radio nowadays without expensive tools, vast patience and intuition, and a rather complete knowledge of these more modern receivers.

Mr. Ghirardi, whose "Radio Physics Course" is well known, has assembled a tremendous book of dope for servicemen. In its 1300 pages he has described servicing equipment, told how to make much of it, what makes radio wheels go round and what makes them stop and how to start them running again. It is up to the minute with a chapter on high-fidelity receivers (anticipating the day when such will be a bit more plentiful than now), much material on cathode ray tubes, 100 pages in a chapter on aligning superheterodynes, data on testing and repairing components, how to diagnose and remedy troubles in automobile sets.

This reviewer spent the better part of a day looking over this book. He now understands why servicemen often feel like daring a chief engineer to try to service one of his own creations. And while this reviewer does not offer to take on practically anybody's radio which has something wrong with it, he does feel that within the pages of this huge book there is all that a service man needs to know to tackle the worst of today's receivers. If he has any fault to find with the book, it is that the author occasionally gets a bit theoretical when he might as easily have been practical. For example it is stated that practically all volume control resistances are of the order of a few thousand ohms (it was our idea that they were nearly all of the order of a half megohm); or when he has the bias resistor in the power output stage (triodes) equal to 50,000 ohms. this seems a trifle high, but of course it was merely given as a numerical case and the answer came out correctly.

As a companion to the text there is a smaller volume by the same author with the aid of B. M. Freed. It is called "Radio Field Service Data" and it gives the i.f. of 2790 models of receivers, grid bias resistor chart, wiring diagrams of automobile ignition systems, trouble symptoms and remedies of over 750 receiver models, etc. It lists at $1.50 and has 230 pages. With these two books it seems possible that one of the engineers mentioned above could go out and make a living at servicing.—*K. H.*

Theory of Alternating Current Wave-Forms

BY PHILIP KEMP, *Head of the School of Engineering at The Polytechnic, London. Instruments Publishing Co., Pittsburgh, Pa. (228 pages, price $4.50.)*

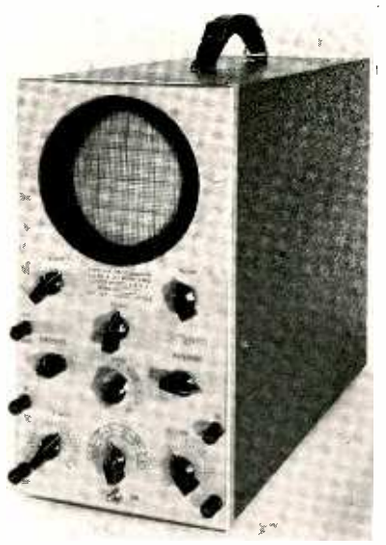
WRITTEN AS THE FIRST VOLUME of a series of monographs on electrical engineering, this book contains information which has heretofore been unavailable except in brief references in periodicals and handbooks. The theoretical and mathematical background necessary for the study of complex waves is introduced in the two chapters which open the book. Following are chapters on the effect of iron and other circuit conditions in producing harmonics, and a chapter on harmonics in polyphase systems. The book closes with an extensive presentation of methods of harmonic analysis.

Although written more or less from the point of view of the power engineer, the radio and communications engineer will be able to adapt this volume to his needs with ease. The presentation is complete, well written, and should be of considerable help in clarifying this important but neglected aspect of electrical engineering.—*D. G. F.*

The Cathode-ray Tube at Work

BY JOHN F. RIDER, *author and publisher, 1440 Broadway, New York, 1935. (322 pages, 440 illustrations. Price, $2.50.)*

IN THIS FIRST complete book on the modern Braun tube published in America, the author proves his thesis, taken from the attractive jacket of the book, that this tube "is destined to become the single most important instrument in the radio man's laboratory."



New Du Mont cathode-ray tube unit

Reading this practical text on the cathode-ray tube, how it works, what it can do, and how to do it, one cannot help but fall in line with Mr. Rider's present enthusiasm for the ultimate importance of these rapidly moving electrons which make visible the invisible.

There are chapters on the tube itself, on sweep circuits, on descriptions of commercial apparatus, on the practical applications (with particular reference to the radio service man and laboratorician) on the alignment of tuned circuits, automobile vibrator testing, testing transmitters, frequency comparison, and some mention of the industrial applications of the cathode-ray tube, the author noting Mr. Stinchfield's article in May 1935 *Electronics,* and Mr. Batcher's papers in *Instruments* appearing at this time.

The book is illustrated throughout with unretouched photographs of oscillograms made in the author's laboratory.—*K. H.*

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Formica has been increasing in use for insulation because of its dependability, and because its cost is in a more favorable relation to other materials for the same purposes than was the case a few years ago.

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THE ELECTRON ART

THIS month three announcements from Europe give television further impetus: A high power 45 Mc transmitter for sending the signals; 405-line images planned for public in England, and a better method of applying fluorescent materials for television work. U-h-f crystals and audio distortion also get proper attention.

IN THE NEWS

PRESS WIRELESS, INC., a radio news service owned by seven American newspapers has obtained permission from the Federal Communications Commission to establish a direct wireless service between New York and Addis Ababa. Station WJS at Hicksville, L. I., has doubled its power to 10,000 watts in preparation for the new service. It is believed that this direct communication will eliminate the possibility of official censorship of Ethiopian war news through the regular European channels.

ACCORDING TO a report supplied by the Royal Italian Embassy in New York, the Italian radio industry employs 5,000 workers, in addition to 320 engineers and experts. The capital invested in the industry approximates 175,000,000 lire, the value of the annual output being around 120,000,000 lire. The annual set production is about 100,000 sets.

INSTALLATION of radio facsimile apparatus on four large passenger liners, as yet unnamed, will be complete before the first of December, according to an announcement by Charles J. Pannill, president of the Radiomarine Corporation of America. The facsimile apparatus will be used to provide weather maps and other navigation information and also a first-class daily newspaper for the use of the passengers. It requires about 25 minutes for the sending of one page of the newspaper. The recorder to be used is that invented by Charles J. Young and described in *Electronics*, November, 1934, pages 338-339.

WORD HAS BEEN RECEIVED by the Electrical Division, Bureau of Foreign and Domestic Commerce, that the development of television in Germany has been transferred from the Ministry of Propaganda and Public Enlightenment to the Air Ministry. What effect this will have on the personnel is not known. The transfer was made by government decree and was not published in German newspapers. Although not officially stated it is believed that this action precedes much larger appropriations for the development of television.

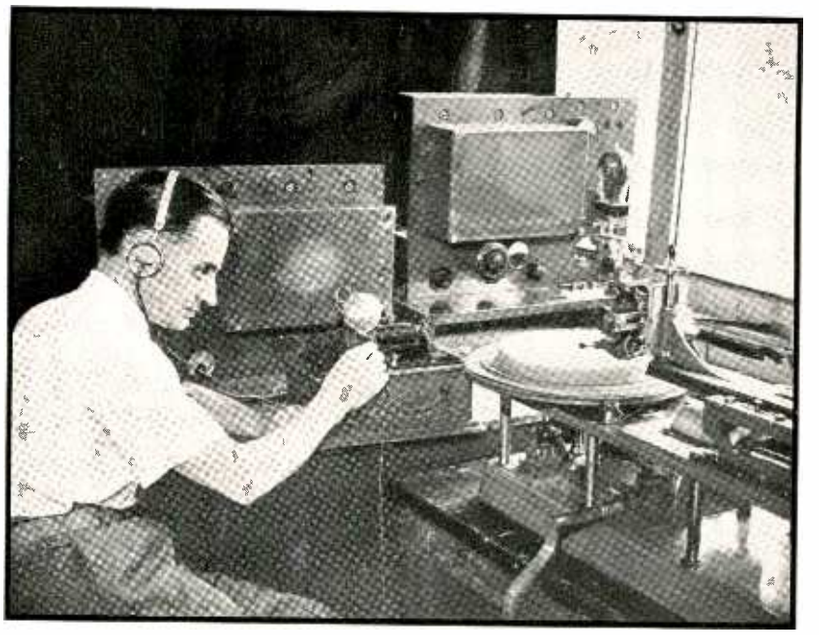
THE LATEST report from Italy states that when Senator Guglielmo Marconi demonstrated his new microwave device to Mussolini last May, motorists on the Rome-Ostia speedway found that their engines suddenly ceased firing. No details about this "amazing" development are available except news reports that it costs about $20,000 and the scheme is capable of transmission over more than 100 miles.

ELECTRICAL RECORDING apparatus of B. A. Proctor & Co., New York revealed that the timing of the fourth round in the Max Baer-Joe Louis fight was 9½ seconds too long. Although this means that Mr. Baer was technically saved by the bell in the fourth round, no protest was forthcoming from the principals involved.

DR. EDWARD C. WENTE, of the Bell Telephone Laboratories, was awarded the annual Progress Medal by the Society of Motion Picture Engineers at the convention held in the Wardman Park Hotel, Washington, D. C., on October 23. Dr. Wente is research physicist in charge of acoustical investigations of the Bell Laboratories. The award was made on the basis of his work on acoustical instruments with special reference to their application in recording, transmission and reproduction of speech and music. His fundamental work in electro-acoustic design is attested by the fact that

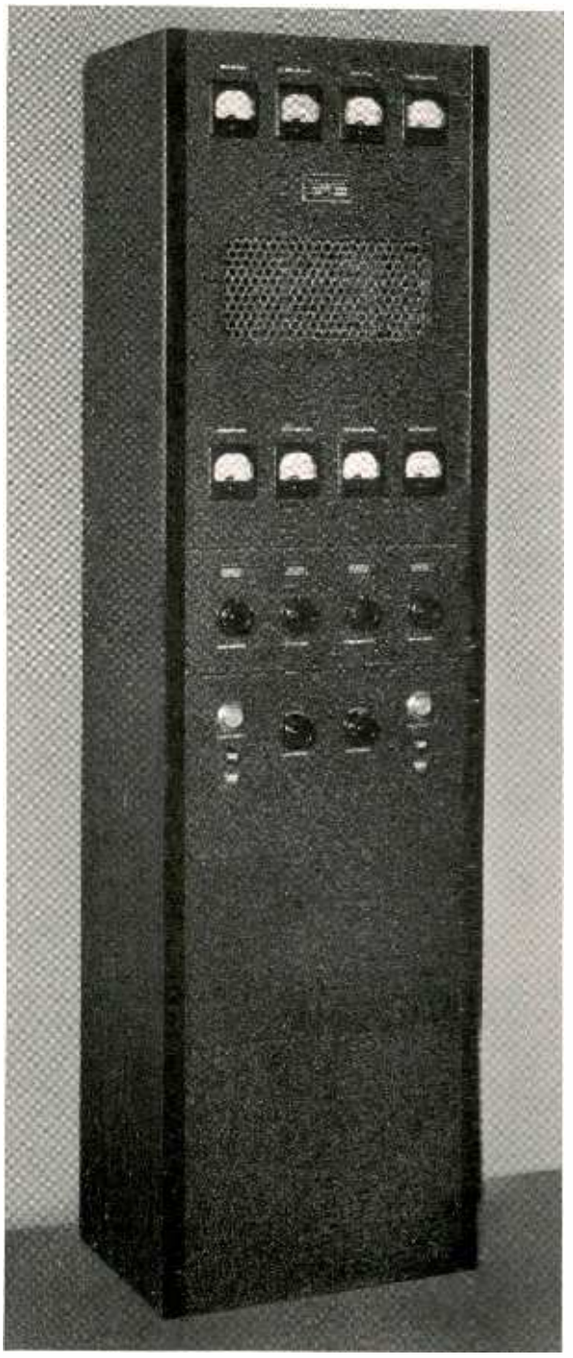
Dr. E. C. Wente

RE-RECORDING QUEEN VICTORIA'S VOICE



The Edison Bell Company of England has undertaken to re-record many of the old and extremely valuable wax cylinders made on Edison's original machine. Here a record of Queen Victoria's message to the Abyssinian Empire is being transferred to a wax disc, preparatory to producing duplicates for general distribution

COLLINS TYPE 300D
100 WATT TRANSMITTER



THE NEW 300D Transmitter exactly meets the requirements of one hundred watt broadcast stations.

FIRST, the transmitter is capable of highly faithful transmission, a definite assistance in holding listener interest.

SECOND, the equipment is simple to install and maintain, and all annoyances of a technical nature are eliminated.

THIRD, the 300D is as reasonably priced as is consistent with best possible design and construction.

★ ★ ★

The 300D has remarkable performance, exceeding all of the new standards of high fidelity transmission. The frequency response at full modulation is uniform within plus or minus 1 db. from 30 to 10,000 c. p. s. The absolute hum level is 60 db. below 100% modulation. (This corresponds to a weighted value of approximately 95 db.) Total distortion components are less than 5% of the fundamental at 100% modulation. The maximum frequency deviation is less than ten cycles. Power is readily increased to 100/250 watts. The design of the transmitter is simple and straightforward so that the excellent performance obtained in the laboratory is readily duplicated day after day in actual operation.

★ ★ ★

The 300D Transmitter is illustrated at the left. An additional cabinet is furnished as standard equipment for mounting the frequency and fidelity monitors. These two units together with the Collins Type 12E Speech Input System form a complete, properly co-ordinated installation.

COLLINS RADIO COMPANY

CEDAR RAPIDS, IOWA

NEW YORK CITY
11 West Forty-Second Street

microphones and light valves universally used in the production of sound motion pictures are the results of his experiments. In addition, the loud speakers used for sound reproduction in a large proportion of the theatres today was designed by Dr. Wente.

A NEW ISOTOPE, known as "heavy neon" or neon 22 has been isolated in its pure state by Dr. Gustav Hertz, a physicist of the Siemens Engineering Works in Berlin, according to an announcement before the British Association for the Advancement of Science in England. Small amounts of the new isotope are being sent to Professor Charles Lauritsen at California Institute of Technology for further experimentation.

CELLOPHANE FILM for use in sound picture recording is being tested by engineers of the RCA Manufacturing Company in cooperation with the Du Pont de Nemours Company. A test film 400 ft. long of 16 millimeter width, and of great durability has thus far been used. The difficulty of producing cellophane strong enough to resist tearing of the sprocket holes has been overcome, according to the report.

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Crystal Control for Ultra-short-waves

[HARALD STRAUBEL] Recent experiments with ultra-short-wave crystals proved that it is now possible to attain a high degree of stability with quartz and tourmaline crystals operating below six meters at natural wavelengths. The research occasioned by the experiments uncovered the hitherto unexplained reasons for the instability of quartz crystals on ultra-short-waves, and for their failure to operate below six meters.

Spark photographs were taken of two oscillating crystals, one quartz, the other tourmaline, and no signs of stress were evident on the surface of the tourmaline. But the surface of the quartz crystal had a complicated distribution of vibrations—evidence of great stress.

These irregular oscillations were generated by the compensation of irregular charges which had collected on the surface of the crystal, and caused a harmful degree of damping. This effect has apparently escaped notice, because damping measurements in the past usually were made with quartz rods or with air-gap mounted crystals having unsilvered surfaces. The difficulty might be overcome by silvering only those parts of the crystal surfaces which show irregularities while oscillating, a laborious procedure, in view of the fact that the pattern of vibrations changes with every change in frequency. Each plate would thus have to be tested individually to determine its peculiarities.

A second, important but easily remediable cause of instability was found in the static capacity of the little crystal plates. This caused a direct short circuit of the alternating feed-back potential appearing between grid and cathode. The capacity could of course be reduced by decreasing the plate diameter, but the reduction would have to be gauged so as to keep a favorable

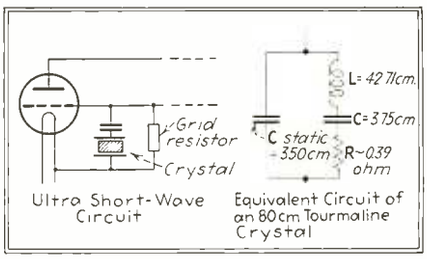


Fig. 1. Crystals in u-h-f circuits

relation between the lines of force permeating the crystal and those appearing along its edges. It was also kept in mind that a crystal's ability to store energy for controlling a transmitter diminishes with every decrease in diameter.

To overcome the harmful effects of this static capacity a series condenser was placed between the crystal and grid (Fig. 1). This arrangement was preferred to one using a choke coil, because of coil size difficulties, and an ohmic resistor was not chosen because of its energy loss factor. During tests with this circuit quartz crystals oscillated with good stability on 5 meters, and as low as 1.66 meters. The fifth harmonic of an 8 meter crystal proved to be similarly stable.

The signal was tuned in with remarkable stability on a receiver located in the same room, and the beat note remained audible during transmitter changes amounting up to 50% in plate potential, and 20% in filament heating potential. Neither the series condenser nor the crystal heating to 60° (C) had any noticeable effect on the frequency.

The tourmaline plates were used in a similar circuit with an RCA 955 (acorn tube). The plate potential was 180 volts at 7 ma. maximum. A tourmaline crystal 1.25 x 10^{-3} cm thick was used to generate the one-meter-wave, and an 80-cm wave was generated with a crystal having a thickness of 1x10^{-3} cms. Great difficulty was experienced in tuning the transmitter particularly because of the very loose coupling between the transmitter and the crystal required for stable operation.

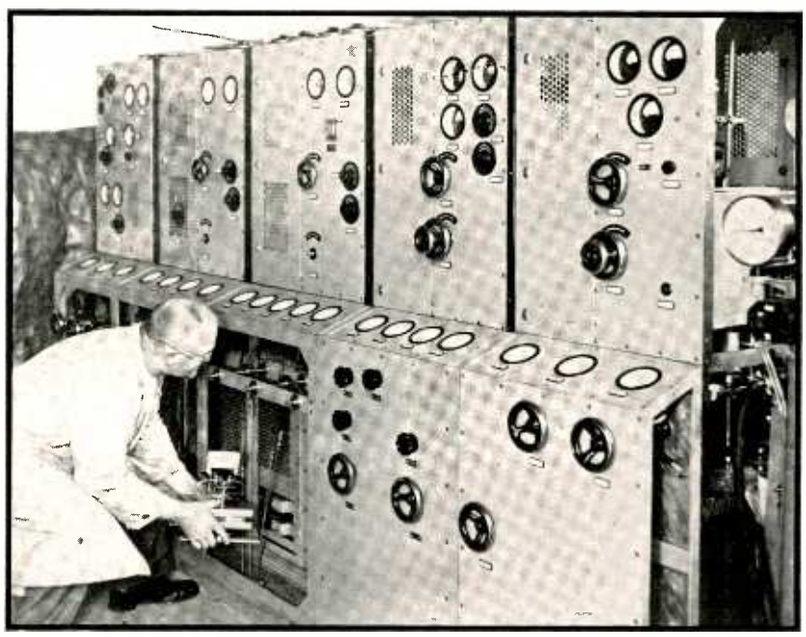
The transmitter was first tuned so as to oscillate without the crystal on the required wavelength. The transmitter stopped operating when the crystal was placed in the circuit, and then oscillated again only when the crystal circuit was properly retuned.

A small vernier condenser (6-15 cm) was connected across a part of the tuning inductance. With a plate voltage of 120 the plate current fell from 10 ma. to 6.5 ma. at resonance.

At one time a transmitter (less crystal) was used to receive a telephone broadcast on 66 cm within the same room. At greater distances the heterodyne beat note was heard clearly.

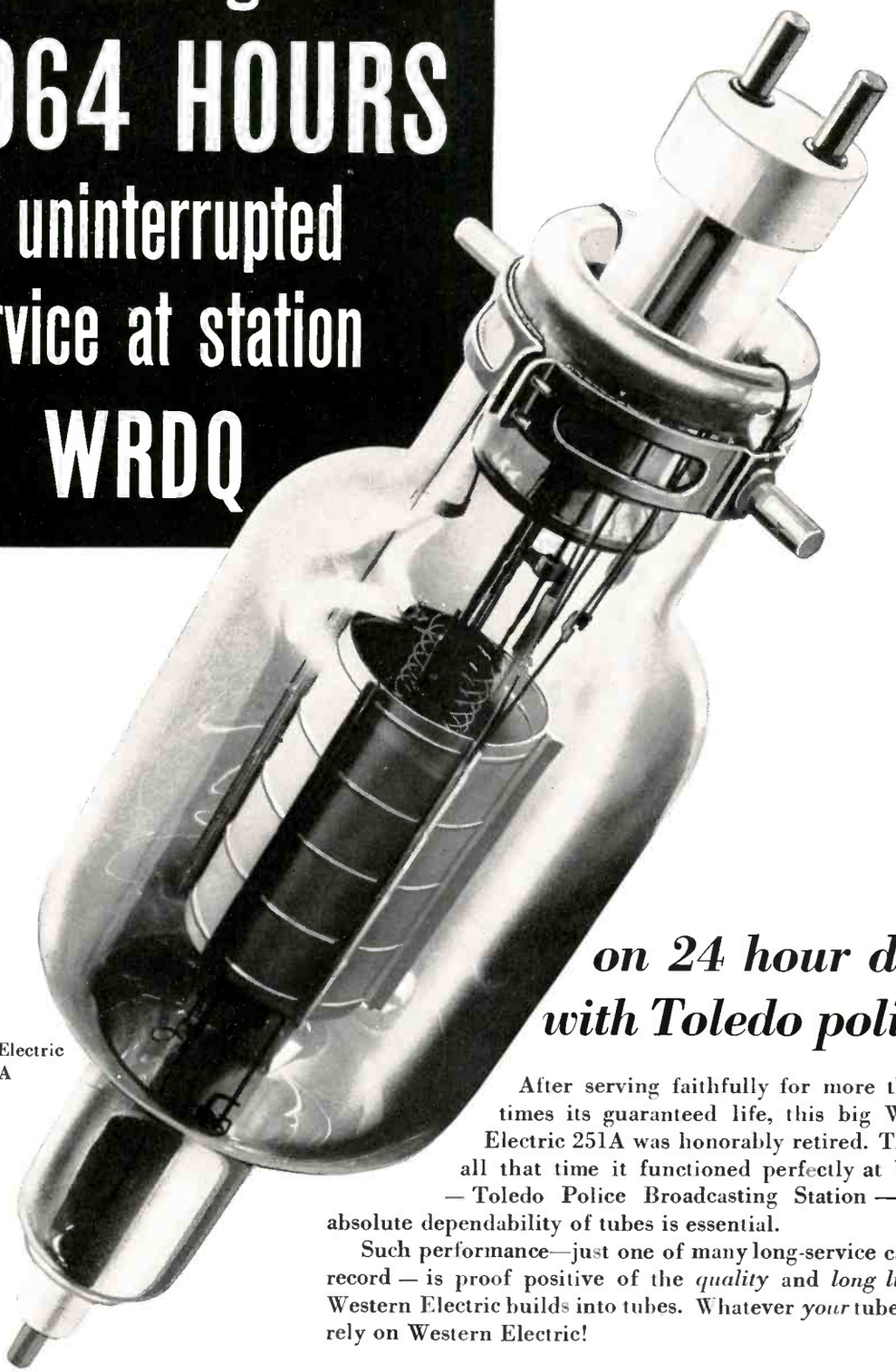
On ultra-short-waves the same potentials may be applied to the crystals as on long waves, and the disruptive strength of tourmaline crystals makes

HIGH POWER ON 45 MEGACYCLES



This 16 kilowatt transmitter, which sends sound-television programs on 6.9 meters, has been heard in America according to unconfirmed reports. It is located in Charlottenburg, Germany

This tube gave 23,064 HOURS of uninterrupted service at station WRDQ



Western Electric
251A

on 24 hour duty with Toledo police!

After serving faithfully for more than 23 times its guaranteed life, this big Western Electric 251A was honorably retired. Through all that time it functioned perfectly at WRDQ — Toledo Police Broadcasting Station — where absolute dependability of tubes is essential.

Such performance—just one of many long-service cases on record — is proof positive of the *quality* and *long life* that Western Electric builds into tubes. Whatever *your* tube needs, rely on Western Electric!

Western Electric

Distributed by GRAYBAR *Electric Co. In Canada: Northern Electric Co., Ltd.*

RADIO TELEPHONE BROADCASTING EQUIPMENT

their thickness dependent mainly upon manufacturing facilities.

It may be of interest that attempts to duplicate these experiments with a Barkhausen tube (Type RS 296) were unsuccessful.—*B. S.*

Hochfrequenztechnik und Elektroakustik, Nr. 1, July 1935, Pages 4-6.

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British Television Plan

ACCORDING TO an announcement issued by the Electrical Division of the Department of Commerce, the Alexandra Palace of London has been definitely chosen as the site of the high definition television station for the London area. Two systems will be tried at this location. The first, known as the Baird system, uses 240 lines, with 25 complete frames per second, while the second, the Marconi-E.M.I. will use 405 lines, 25 pictures per second interlaced two to one.

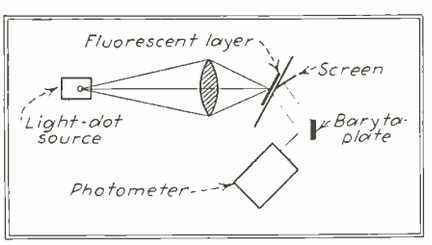
• • •

Halation Interference In Fluorescent Screens

[MANFRED VON ARDENNE] The arrangement shown below was used to determine the strength (in per cent) of halation interference in a fluorescent light spot of given intensity. The photometer was purposely inclined as shown, 45° from the optical axis of the fluorescent layer, to avoid interference from light rays straying through the fluorescent screen. For the same reason a screen was placed right along the path of light, between the barytawhite-plate and the object.

Microphotographs of various fluorescent screens were inspected and measurements indicated that halation interference was considerably smaller in screens whose crystals had only a light optical contact with their glass holder (or with the binding agent) than in fluorescent screens whose crystals had been sintered (slagged) into their glass housing.

There was from 25%-28% halation with sintered crystals, while the screens whose crystals had been dusted on,



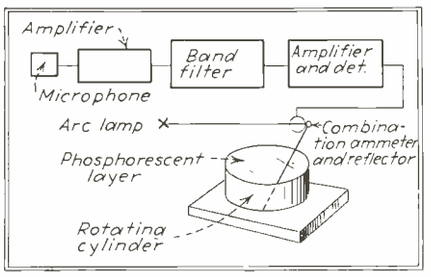
Arrangement for testing fluorescent layer

showed only from 1½% to 4%. The low-halation screens incidentally showed a black and white contrast of over 50:1, which is satisfactory for ordinary television work.—*B. S.*

Hochfrequenztechnik und Elektroakustik, July 1935, Pages 1-4.

The Echo Period and Audience Sound Absorption In Concert Halls

[ERWIN MEYER and VILHEML JORDAN] Before the degree of audibility in concert halls and theatres can be determined, the audience's capacity to absorb sound must be measured. A recently developed method made it possible to carry on extensive tests during performances without the slightest annoyance to the listeners. The testing apparatus consisted of little more than a self regulating amplifier, and a detector with a logarithmic scale. The orchestra sounds were delivered through an amplifier to a sharply tuned bandfilter, and a switching arrangement enabled the operator to select the combinations of condensers and inductances required to pass the one desired test frequency to the second amplifier. The rays of an arc lamp were trained on the indicating arm of the output ammeter and from there they were deflected so as to fall on a rotating phosphorescent glass cylinder.



Arrangement of rotating cylinder

When the music suddenly ceased after a fortissimo, the decreasing strength of the echo was read and measured graphically on the cylinder, and the phosphorescent action was even slow enough to permit the photographing of the recordings. The measurements made in the Philharmonie and in the State opera, both in Berlin, showed that the echo period in a filled hall increases as the sound frequency decreases. The calculated sound absorption per person was found to be much below the general estimate, and at some low audio frequencies the audience had the effect of decreasing any existent damping!—*B. S.*

From: *Elektrische Nachrichten Technik;* July 1935, Pages 213-220.

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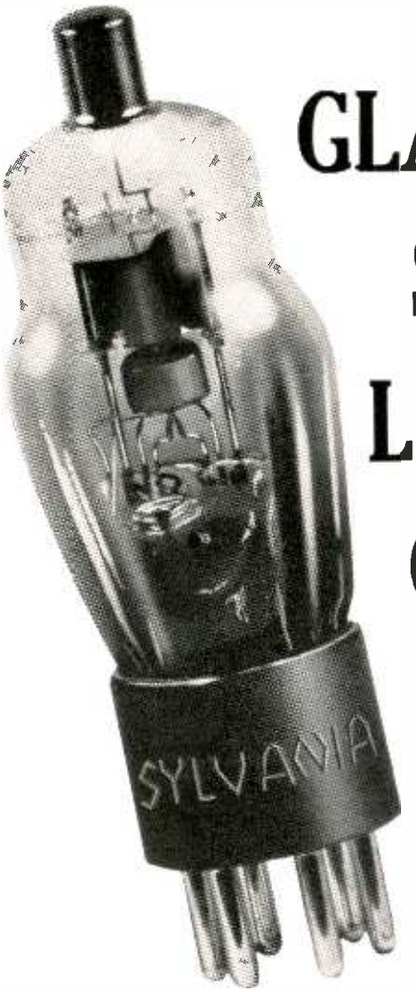
Distortion Factor and Summation Tones in Radio Receivers

W. GRAFFUNDER, W. KLEEN AND W. WEHNERT
Telefunken Laboratory

WITH RESPECT to distortion the output tube is in the most dangerous position since it has to handle high voltages, and there is no chance of suppressing non-linear distortion by means of small filters and tuned circuits as can be done in the r-f stages. In view of the low efficiency (about 5 per cent) of the common loudspeaker, the output tube has to provide at least 3 watts. While

THE "SALLE DE T. S. F." OF THE NORMANDIE

The communication center of this great ship contains every possible facility for marine radio, even to complete soundproofing of the room



GLASS AND METAL SYLVANIA LEADERSHIP CONTINUES

HYGRADE SYLVANIA CORPORATION TAKES CONSIDERABLE PRIDE IN ITS RECORD OF 3 SUCCESSIVE YEARS AS LEADERS IN THE PRODUCTION OF TUBES FOR ORIGINAL EQUIPMENT

● We feel safe in saying that our share of the *total* tube business will be greater in 1935 than ever before. We believe that we have sold *more* tubes, because we have made *better* tubes.

We are in a position today to satisfy the most stringent requirements of *any* set manufacturer for either glass or metal tubes. We offer not only *better* tubes, but a thorough Engineering Service that many have found to be of inestimable value.

Please address inquiries to our New York Office at 500 Fifth Avenue.

SYLVANIA

(Reg. U.S. Pat. Off.)

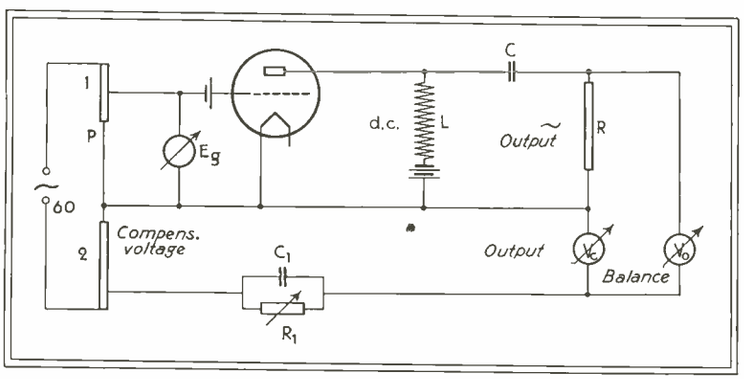
THE SET TESTED RADIO TUBE

FACTORIES: EMPORIUM, PA. SALEM, MASS. ST. MARY'S, PA.

Photographers will realize how brilliant this television image must have been to make possible this photo, made from one single scanning of a 180 line, 25 frame picture at the von Ardenne Laboratories in Berlin

a distortion factor of 4 to 10 per cent is considered as admissible, it is doubtful whether this factor is a true measure of the distortion as it affects the ear, because the tones representing sums and differences of frequencies arriving at the same time upon the grid of the last tube are without doubt more disagreeable to the ear than mere harmonics.

As long as no overtones appear in the output circuit supposed to consist of an ohmic load, the a-c output and the total d-c power are readily obtained for a given operating point O from the plate current versus plate voltage curve of the tube for different grid biases by



the triangle and the rectangle method (see Keith Henney, "Principles of Radio").

When a harmonic, in particular the third overtone, is present this simple method fails; to determine the a-c output, five plate current-plate voltage curves must be available, i_5 the curve with the highest positive (or least negative) value of the grid with the a-c wave applied to it, i_3 the curve for the normal grid bias, i_1 the curve for the most negative voltage which the grid assumes, and i_4 and i_2 for voltages of the grid falling half-way between the former values. The amplitude A_1 of the fundamental is then given by

$$A_1 = \frac{1}{3}(i_5 + i_4 - i_2 - i_1),$$

that of the second and third harmonic by

$$A_2 = \frac{1}{2}\left(\frac{i_5}{2} - i_3 + \frac{i_1}{2}\right)$$

$$A_3 = \left(\frac{i_5}{6} - \frac{i_4}{3} + \frac{i_2}{3} - \frac{i_1}{6}\right)$$

The tube curves must be known with great accuracy.

A simple experimental method for determining the output is to insert high self-inductance into the lead from the d-c source so that the a-c plate current flows practically over the large condenser C and across the load R. The voltage across R is brought to zero (in the case of a pure sine wave) or to a minimum (in the case the output wave is a composite wave) by applying an a-c voltage in opposite phase from the same potentiometer that supplies the grind swing. This voltage is measured by the a-c voltmeter V_c whereas V_o indicates the balance without absorbing energy. Provided that these meters are square-law instruments (hot-wire instrument, electrostatic or tube voltmeter with square law), the ratio of the lowest voltage indicated by V_o to the voltage indicated by V_c is directly equal to the distortion factor k_1 that is to the square root of $(A_2^2 + A_3^2 + A_4^2 + \ldots)\, A_1^2$. To reduce the amount of non-ohmic load, high audio frequencies are to be recommended for this work; the wave shape of the frequencies is, however, less pure as a general rule than that readily obtainable for 60-cycle current, and current of this frequency can be used when C and L are made large. The capacitive load causes the output voltage to be ahead of the input voltage; a phase-shifter C_1R_1 corrects the difference. When the input voltage contains overtones, then the circuit becomes unable to furnish the distortion factor.

The question now arises whether the computed or measured distortion factor permits deduction of the intensity of the summation or difference tones in the case where, in place of a single frequency or amplitude A_1, two frequencies of amplitude B and nB should act at the same time upon the grid, assuming $A_1^2 = B^2\,(1 + n^2)$ in order to simplify the formulas.

In the case of several frequencies the distortion factor k_2 will have to be defined as the square root of the sum of all the squares of the amplitudes of the higher overtones to the sum of the squares of the fundamentals, the combination factor K as the square root of the ratio: sum of the squares of all the summation and difference tones to the sum of the squares of all the fundamentals.

When near the operating point the tube current can be represented by a constant plus a linear and a quadratic function of the grid voltage—

$$i_p = i_3 + a\,(e_g - eg_o) + b(e_g - eg_o)^2$$

then the distortion factor k_2 is given by

$$k_2 = k_1\sqrt{1 - \frac{2}{\left(1 + \frac{1}{n}\right)^2}}$$

whereas

$$K = k_1\sqrt{\frac{}{\left(1 + \frac{1}{n}\right)^2}}$$

The sum of $k_2^2 + K^2$ may become 2.6 times as large as k_2^2 alone. When the square term in the expression for i_p is replaced by a cubic term, still more distortion may result.

The behavior of the tube finally may be studied by applying the input a-c voltage to one pair of a cathode ray tube and the output voltage to the other pair; the plate current versus grid voltage curve appears then on the screen. When a pentode and a small load is used the curve recalls the three-halves power law obtained for a triode; when the load is increased, the upper portion of the curve shows a sharp bend and ends in a flat portion. When instead of the a-c plate voltage, the unbalance representing the distortion factor is applied to the second pair of plates, the deviation of the resulting figures from a straight line indicates the presence of overtones; a flat trough means that the second harmonic is present, a saw-toothed shape that the third harmonic is prominent. By compensating phase differences very sharp curves can be obtained allowing a complete numerical analysis as for ordinary 60-cycle current.—*Telefunken-Röhre* No. 4: 142-163. April, 1935.—*R. R.*

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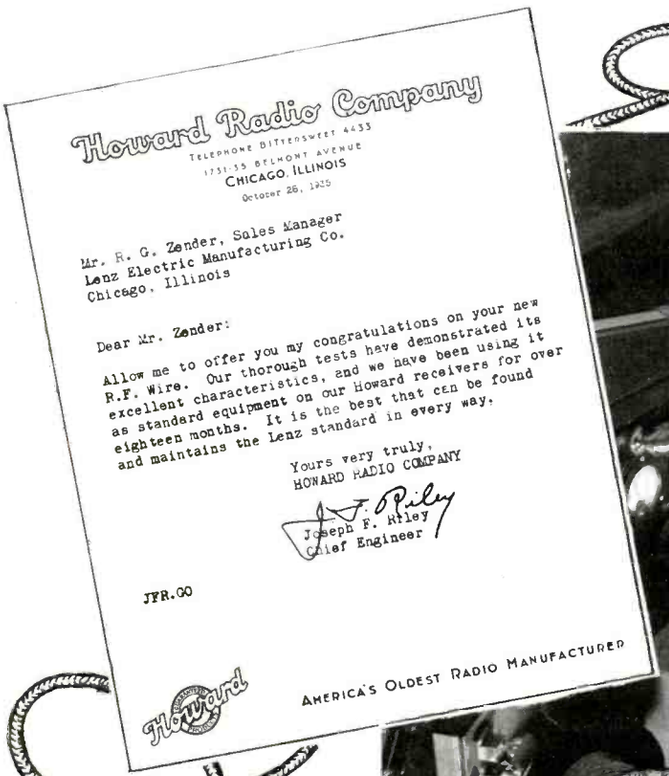
70-Tube Receiver

A RECEIVER CONSISTING of over 70 tubes is shown by the Philips Company, Eindhoven, Holland, at the Brussels Exhibition. Cathode ray oscillographs, inserted at suitable points illustrate to the public the working of the different parts of a receiver.

Dependable Lenz Wire



Howard Radio Company

TELEPHONE BITTERSWEET 4433
1731-35 BELMONT AVENUE
CHICAGO, ILLINOIS

October 26, 1935

Mr. R. G. Zender, Sales Manager
Lenz Electric Manufacturing Co.
Chicago, Illinois

Dear Mr. Zender:

Allow me to offer you my congratulations on your new R.F. Wire. Our thorough tests have demonstrated its excellent characteristics, and we have been using it as standard equipment on our Howard receivers for over eighteen months. It is the best that can be found and maintains the Lenz standard in every way.

Yours very truly,
HOWARD RADIO COMPANY

Joseph F. Riley
Chief Engineer

JFR.GO

Howard

AMERICA'S OLDEST RADIO MANUFACTURER

CONTRIBUTES TO *the famous* HOWARD *Quality*

LENZ R. F. CIRCUIT HOOK-UP WIRE

Selected by leading manufacturers for these outstanding Dielective Characteristics under severe atmospheric conditions.

At 120° F. 90% R. H.

- ★ Power Factor—1% at 25 meters (12 Megacycles) immersed in mercury.
- ★ Capacity (to ground)—28 MMF. per foot at 25 meters (12 megacycles).
- ★ Moisture Absorption—less than 1% by weight.

We invite you to make comparative tests of Lenz R. F. Circuit Hook Up Wire in your own laboratory.

HOWARD, oldest American radio manufacturers, has always built receivers of outstanding quality. Much of the superlative performance and fine workmanship, is due to the very strict standards of material quality set up for Howard production. Only materials that can contribute to the superlative quality of Howard's fine receivers, earn the approval of Mr. J. E. Riley, Chief Engineer. He was among the first of many users to recognize the superior characteristics of Lenz R. F. Circuit Hook-Up Wire and adopt it as standard for Howard receivers.

LENZ ELECTRIC MANUFACTURING CO.
1751 N. WESTERN AVENUE, CHICAGO, ILL.

LENZ

ESTABLISHED 1904

VISIT THE LENZ BOOTH NO. 27 AT THE I.R.E. CONVENTION, NOV. 18 to 20

LENZ ELECTRIC MFG. COMPANY
1751 N. Western Ave., Chicago, Ill.

Gentlemen: Please send me FREE 10-foot sample of Lenz R. F. Circuit Hook-Up Wire.

Size.....Solid ☐ Stranded ☐
Name.....
Company.....Dept.....
Address.....
City.....State.....

MANUFACTURING REVIEW

Names in the News

✦ **Mr. Douglas Loukota,** formerly with the Communications Engineering Division of TWA, Inc., is now with the Cannon Electric Development Co. in a sales and engineering capacity, devoting a major part of his time to airplane fittings and devices.

✦ **Virgil M. Graham,** who recently joined the staff of the Hygrade Sylvania Corporation, has been appointed head of the Sylvania Application Laboratory at Emporium, Pa., in which capacity he will act as consultant to radio manufacturers and engineers. Mr. Graham will be assisted by Dr. Ben Kievit, Jr., who will continue as direct supervisor of the work conducted in the laboratory.

✦ **Gertrude C. Freytag,** in charge of client service of the Fensholt Co., advertising and sales promotion counselors, of 360 N. Michigan Ave., Chicago, was recently made vice president of that agency. In her new capacity, Miss Freytag will supervise all production and service activities.

✦ **Stanley A. Harris** has been appointed sales representative for Sylvania receiving tubes in the New England territory. Mr. Harris, who will make his headquarters at the Hygrade Sylvania Boston office at 10 Post Office Square will be assisted by Mr. C. J. McLean.

✦ **Milton J. Shapiro** has been appointed district sales manager for the Radiart Corporation of Cleveland in charge of vibrator sales in the Philadelphia territory, with headquarters in Philadelphia.

✦ **Mr. Erich Fetz** has joined the metallurgical staff of the Wilbur B. Driver Co., Newark, N. J., manufacturers of resistance alloys. Mr. Fetz, who has had extended metallurgical experience in this country and abroad, will assume the duties of research metallurgist.

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Industry Notes

The Ohmite Manufacturing Co., Chicago, Ill., has moved into a new and larger plant at 4835 Flournoy St., according to an announcement by D. T. Siegel, general manager.

Walter H. Candler, president of the Candler System Co., announces that he has moved his school to Asheville, N. C. The Candler System of High Speed Telegraphing Instruction, was formerly located in Chicago.

The Technical Appliance Corporation has moved from Long Island City to 17 East 16th St., New York. The new quarters provide three times as much floor space and additional production facilities.

The Federal Trade Commission has issued a complaint against the National Electrical Manufacturers Association, charging unlawful combination to restrain competition in the marketing of power cables and wire products. Sixteen prominent manufacturers of wire and cable are mentioned in the complaint.

The factory of the Universal Microphone Co., Inglewood, Calif., has been provided with additional facilities for the manufacture of Silveroid recording discs intended for instantaneous recording and play back, according to James R. Fouch, president.

Attention is directed to the fact that there are two firms who manufacture machinery for the production of radio tubes operating under the name of "Eisler:" the Eisler Electric Corporation, 538 39th St., Union City, N. J., and the Eisler Engineering Co., 768 So. 13th St., Newark, N. J.

General Electric Co., Schenectady, announce that the sales for the first nine months of 1935 exceeded by 23 per cent those for the corresponding period last year, according to President Gerard Swope.

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New Products

Tubes

U-H-F Power Tube. A filament type power tube, particularly suitable for use as an oscillator at ultra-short wave lengths (6 meters). Plate and grid

connections brought out at top of bulb. Type No. WL-455. Manufactured by the Westinghouse Electric & Mfg. Co., Pittsburgh, Pennsylvania.

New Photronic Cell. A dry plate photronic cell, which provides increased current output over the regular photronic cell, is announced by the Weston

Electrical Instrument Corp., Newark, N. J. The new cell, known as Type 2, is not quite so stable as the regular type but will be found suitable where high output is more essential than strict permanence, especially for use in low illumination.

Sound System Photocells. Three types of vacuum photo cells for use in replacements in all types of sound motion picture reproduction apparatus. Also a filament type exciter lamp, and a mercury vapor battery charging bulb. All manufactured by The Sonolux Co., East Newark, N. J.

New Type 5Z4. A new 5Z4 metal tube rectifier 3¼ in. high, 1⅛ in. in diameter, filament drain 1.5 amperes, similar in characteristics to old type 5Z4. Manufactured by the Hygrade Sylvania Company, Emporium, Pa.

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Components

Octal Socket. A new octal socket, type 39, having a bow action spring contact, with low contact resistance, uniform pressure and high quality moisture-proof bakelite. Manufactured by the Albert W. Franklin Mfg. Corp., 137 Varick St., New York.

Phonograph Motor. A heavy synchronous motor for high quality disc recording, announced by the Sound Apparatus Co., 150 West 46th St., New York City, having turntable diameters of 12 or 16 in. and consuming 60 to 95 watts of power.

Paper Condensers. A series of uncased paper condensers and tubular

THE HOUSE OF CLAROSTAT

for

INBUILT PROTECTION

CLAROSTAT'S facilities for the production of essential components include an experimental laboratory equipped with the latest types of precision testing instruments and staffed with engineers of broad technical experience.

Much of the machinery used on Clarostat's production line is of special design in order to insure the highest degree of accuracy. A constant inspection of parts as they move through production insures the maintenance of Clarostat's exacting standards of precision.

The painstaking care involved in the production of Clarostat Products is your guarantee of uniform high quality. You can therefore depend on the House of Clarostat and the components that leave its shipping department for dependable service.

Clarostat's complete engineering cooperation and manufacturing facilities are available to work with you on standard or special resistor requirements for radio, sound, communication or industrial application.

Write for technical data and samples of Clarostat Products.

ACTUAL SIZE

NEW—LINE VOLTAGE DROPPING RESISTOR

Designed for use with 0.3 amp. radio tubes with terminal prongs to fit the new metal tube octal sockets for ease of installation. Satisfies requirements of Underwriters.

These units are available in compensated resistance values providing proper voltage drops for heater circuits having one to seventeen 6.3 volt tubes when used on 117.5 volt lines. Pilot light resistor sections for use with 6-8 volt, .250 amp. lamps may be incorporated.

Available in 5 or 8 prong bases. Write for complete list of types.

CLAROSTAT MFG. CO., INC.
287 North 6th Street
BROOKLYN, N. Y.

CLAROSTAT

paper condensers, working voltage from 400 to 1,000 volts, depending upon size and type. Capacities from .001 to 4 mfd. List price from 20 cents to $2.20. Manufactured by Morrill & Morrill, 30 Church St., New York, N. Y.

Isolantite Socket. A high frequency socket with a circular "Guide Groove" for standard tubes of the 4, 5, 6 and 7 prong base. Manufactured by the

Hammarlund Manufacturing Co., 424 W. 33rd St., New York City.

½ Watt Carbon Resistors. A ½-watt carbon resistor enclosed in a ceramic case, overall dimensions ⅜ x 1⅛ in. Will carry 100% over load. R.M.A. color coding. Available in all resistance

values from a few ohms to several megohms. Manufactured by the Erie Resistor Corp., 644 W. 12th St., Erie, Pa.

Mallory Grid Bias Cell. A small metallic cell suitable for providing fixed grid bias voltage for those stages where no grid current is drawn. Cells provide approximately 1 volt (open circuit) and may be connected in series. Manufactured by P. R. Mallory & Co., Inc., Indianapolis, Ind.

Iron Core I.F. Transformers. I.F. Transformers having polyiron cores, and measuring 1¼ in. square by 2½ in. high, including trimmer. Designed for use with metal tubes. Manufactured by the Aladdin Radio Industries, 466 West Superior St., Chicago.

Power Cord Trim. A rubber binder for preventing frayed edges in braided wire connections, for binding, fastening and insulating the ends of electric wires. Distributed in U. S. by George Walker, 30 Church St., New York City.

Interference-Suppressor Condensers. A line of interference-suppressor condensers for use in auto radio installations, capable of withstanding extremes of temperature and vibration. Manufactured by the Aerovox Corp., 70 Washington St., Brooklyn, N. Y.

Trimmer Condensers. A line of ceramic and Bakelite insulated trimmer condensers having operating capacities as low as 4 mmfd. and as high as 2,100. Manufactured by the DeJur-Amsco Corp., 95 Morton Street, New York City.

Transmitting Equipment

Circuit Breakers for Radio Speech Circuits—A new type circuit breaker, type AY-1, designed to replace the switch and fuse used in control circuits of speech equipment in broadcast stations, for the protection of microphones, amplifiers, volume indicators and other speech input apparatus. The circuit may be restored to service by pressing the button on the breaker. The direct-current breakers have a current rating of 5 amp. at 14 volts, with calibrated tripping range of 7.5 to 8.5 amperes, or current-carrying rating of 0.1 ampere at 400 volts with a calibrated tripping range from 1.7 to 2.3 amperes. Manufactured by the General Electric Co., Schenectady, N. Y.

Compact Transmitter—A new small size transmitter type 45-A having 40 watts telephone and 125 watts telegraph output, containing power supply and all auxiliary equipment self-contained except microphone and key is announced by the Collins Radio Co., Cedar Rapids, Iowa. Frequency range from 1,500 kc. to 30,000 kc. Control grid modulation is used with a modulation capacity of 100 per cent. Total amplitude distortion is 10 per cent maximum at 90 per cent modulation. Noise level, 55 db below output level. Weight 130 lb. Supply of 110 volts 60 cycles a.c., 6.5 amperes line current for telegraph and 4.5 amperes for telephone. Dimensions 21½ in. wide, 18 in. deep and 12 in. high.

Power Amplifier—A radio frequency power amplifier, having an output up to 1,800 watts, on frequencies from 1.5

to 15 mc. with 130 watts excitation required for full output, is announced by the Audio Products Co., 485 West Second St., Los Angeles, Calif. Net price, less tubes, $100 with one set of coils. Panel rack occupies a table space 12 x 19. 36 in. high. Type HK-354 Gammatrons tubes. Eimac 150T or RCA852 tubes may be used.

Glass & Mica Capacitors—The Leichner Electric Co., Fort Wayne, Ind., announces a series of flint glass condensers ranging in capacity from .0005 to .02 microfarads and ranging

in price from $1.05 to $4.25 depending upon the capacity and voltage rating. Voltage ratings from 1,750 volts d.c. to 7,500 volts d.c. Supplied in white porcelain cases.

• • •

Audio Equipment

Spheroid Microphones. A non-directional crystal microphone of spherical construction having high fidelity characteristics and high level output. Man-

ufactured by The Shure Bros. Co., 215 West Huron St., Chicago, Ill. The sphere is 2¼ in. in diameter; sound enters through horizontal annular slots.

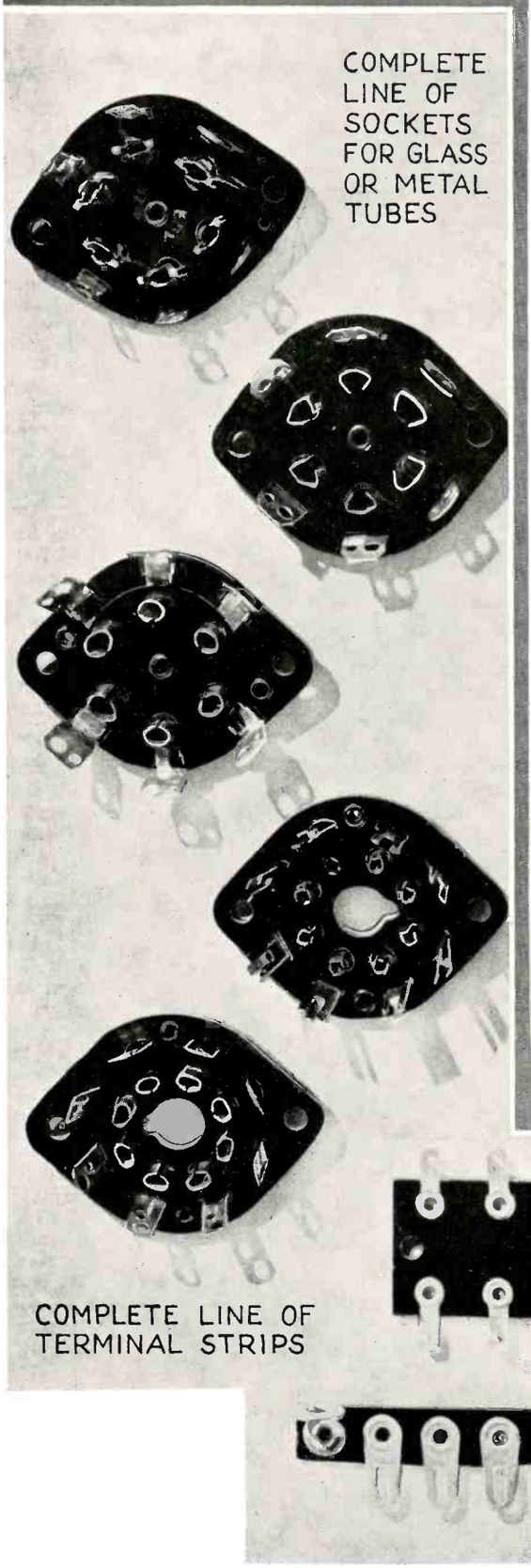
Dual Diaphragm Microphone. A crystal microphone having two opposed diaphragms controlling one crystal. Frequency response flat from 20 to 5,000 c.p.s. with a gradual rise to 10,000 c.p.s. Output level approximately —64 d.b. Manufactured by the Astatic Microphone Laboratory, Inc., Youngstown, Ohio.

Moving Coil Microphone. A moving coil dynamic microphone of the low impedance type and of rugged construction is announced by the Thomaston Laboratories, Inc., 220 West 42nd St., New York City. The microphones are fitted with a stand and Cannon plug at slight extra cost.

Sound Cell Microphone. A crystal microphone designed for use in the fields of public address, amateur phone transmission and remote radio broad-

WHAT NEW SOCKET DESIGNS . . .

ARE IN THE OFFING FOR HOME AND AUTO RADIO IN 1936 ?



Advance information now ready for radio engineers.

Samples will be submitted for test purposes to recognized set manufacturers.

• • • • • •

and

an entirely new and better auto-radio socket.

Before you design your new automobile radio chassis, ask us for full information and technical data on the NEW FRANKLIN AUTO-RADIO SOCKET which features:

—the least amount of space in chassis ($1\frac{1}{4}$" overall)

—voltage breakdown test 5000 v. (twice that of normal breakdown)

—a different method of socket assembly to the chassis effects definite savings in time, labor, material and space.

INVESTIGATE this new and improved socket.
Send for samples.

ALBERT W. FRANKLIN MFG. CORP.
137 VARICK STREET
NEW YORK, N. Y.

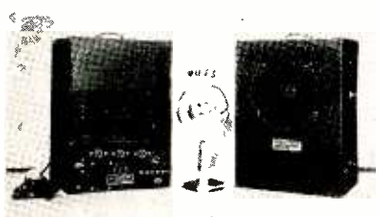
cast pick-up where a good but inexpensive microphone is important. Output level —71 d.b., weight 3 oz. List price $45. Manufactured by the Brush Development Co., East 40th St. and Perkins Ave., Cleveland, Ohio.

Sound Level Meter. A portable and simple sound level meter making use of the single vacuum tube which provides a range of 18 d.b. on its meter scale is announced by the Electrical Research Products, Inc., 250 W. 57th St., New

York City. A new type carbon microphone is mounted in the face of the carrying case, which contains battery, tubes and all necessary accessories. Known as model RA-198. Weight is 8½ lb.

Recording Discs. Aluminum recording discs coated with acetate for instantaneous recording and playback. Lateral recording up to 6,500 cycles; hill-and-dale recording up to 9,000 cycles. Surface noise below that of standard shellac records. Manufactured by the Presto Recording Corp., 139 W. 19th St., New York City. Available in sizes from 6 to 16 in.

Portable Two-Speaker P. A. System. A public address system for 110 volt or battery operation weighing 40 lb. complete with two speakers. Suitable



for use with carbon or crystal microphones. Manufactured by the Miles Reproducer Co., Inc., 112 W. 14th St., New York.

Microphone Stands. A series of microphone stands expressly designed for use with Brush microphones is announced by The Brush Development Co., Cleveland, Ohio. Also prices and capacities of single and two conductor rubber covered shielded cable for use in microphones. Price ranging from 6 to 10 cents per foot, announced by the Brush Development Co.

Directional Speaker Baffle. A floor stand and directional speaker baffle for use with dynamic loud speakers, suitable for portable installation, rental or temporary installation and for permanent installations where insufficient wall or ceiling space is available, is announced by the Macy Engineering Company, 1451 39th St., Brooklyn, N. Y. Models available for all size of cone speakers. List price $40, baffle and housing alone $15.

Microphone Stands. A series of microphone stands for suspending carbon crystal and dynamic microphones. Announced by Eastern Mike-Stand Company (formerly Eastern Coil Co.), 56 Christopher Ave., Brooklyn, N. Y. Stand accessories such as plugs, cable fasteners and swivels are available.

Hand Set Unit. The Lifetime Corp., 417 Twelfth St., Toledo, Ohio, announces a transceiver hand set unit, having a 200-ohm single button microphone, frequency response essentially flat to 4,000 cycles, and a receiver of 2,000 ohms resistance, especially designed for this unit. The net price is $11.95.

• • •

Materials and Fittings

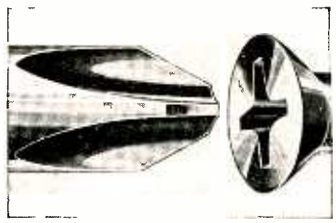
New Tapping Screw — The Shakeproof Lock Washer Co., 2501 N. Keeler Ave., Chicago, Ill., announces a new tapping screw with a standard machine

screw thread. A slot in the body of the screw provides spring action, and the material cut in tapping is directed into the slot away from the cutting edge.

High Permeability Alloy—The Allegheny Steel Co., Brackenridge, Pa., announces Allegheny Mumetal, a nickel iron alloy of high permeability, for use at flux densities under 5,000 gauss. Maximum permeability as high as 100,000 is developed in this material, with initial permeabilities as high as 30,000. The electrical resistivity is 45 microhms per cm^3. A series of data sheets giving magnetic curves of this material is available from the manufacturer.

Electro-Plate Mesh—The Electrolytic Products Corporation, 250 West 39th Street, New York, N. Y., announces a new process by which smooth surface fine mesh metallic screens are produced by electrolytic deposition, as a single piece of metal. By this process in general the hole size can be made as small as desired, irrespective of the mesh, within the limits of the material.

Recessed-Head Screws—The American Screw Co., of Providence, R. I., has announced a line of screws and



bolts with a newly designed recessed head which holds the screw to the driver and provides automatic self-centering. This method of construction provides positive control of the direction in which the screw is driven and also results in a strong head.

White Fiber Material—A hard white vulcanized fiber, furnished in sheets or coils in thicknesses from 0.005 in. having good mechanical and electrical properties is announced by the Spaulding Fibre Co., 484 Broome St., New York, N. Y.

Resistance Alloy—"Kanthal," a resistance alloy for use in electrical furnaces where temperatures up to 2,417 deg. F. are required, for heating elements in domestic appliances and wherever high specific resistance is advantageous. Advantages claimed for this alloy as against nickel-chromium alloys are longer life, lower costs and higher temperature operation. Manufactured by C. O. Jelliff Mfg. Corp., Southport, Conn.

Brass Die Casting Alloy—"Doler-Brass," a new casting alloy manufactured by the Doehler Die Casting Co., 386 Fourth Ave., New York, N. Y., having a light yellow color, impact strength of from 30 to 36 ft. lb., and a tensile strength from 65,000 to 75,000 per sq.in. with a yield point of 30,000 to 40,000 lb. per sq.in. The alloy contains copper, zinc and silicon, and is especially adapted to die castings.

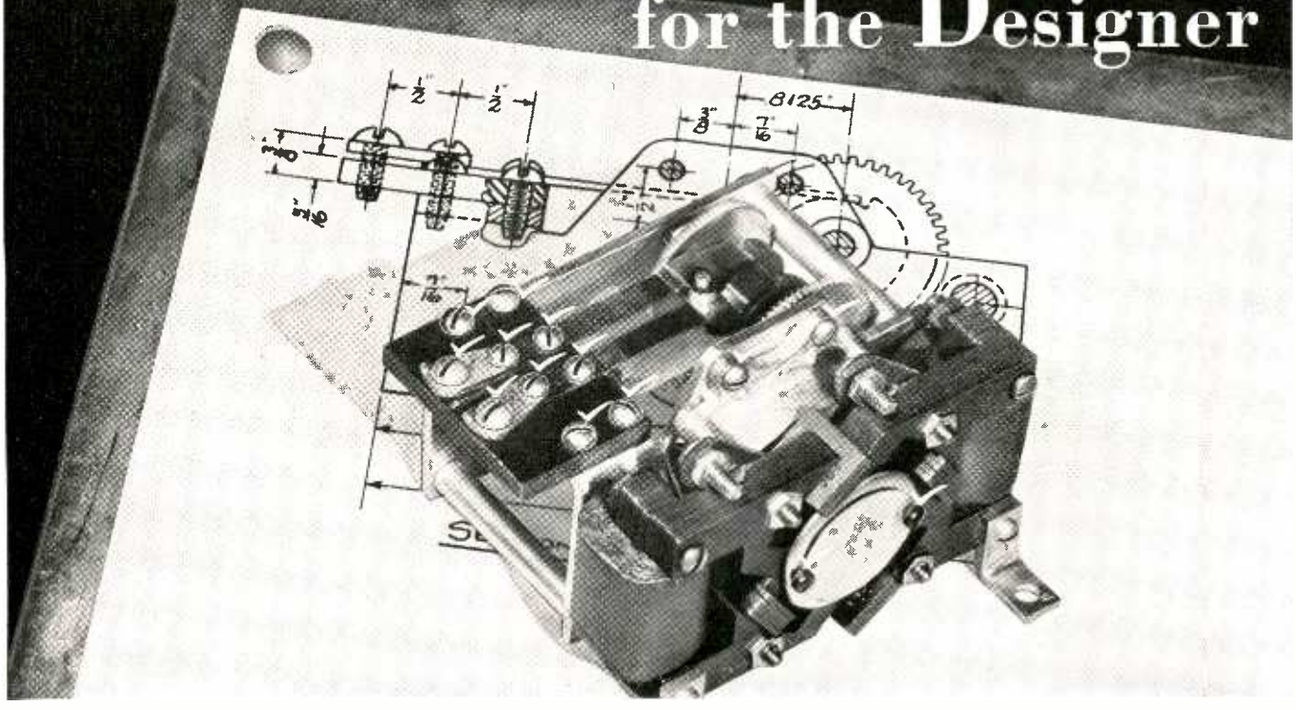
• • •

Measuring Equipment

Photo Electric Reflectionmeter — A Reflectionmeter designed for the determination of whiteness consisting of a self-generating photoelectric cell, a microammeter, a small storage battery and controls. The light source is reflected from the surface to be measured to the cell. Colored filters are available for the measurement of various spectral ranges. Pfaltz & Bauer, Inc., 300 Pearl St., New York.

Cathode-Ray Oscillograph—A portable cathode ray oscillograph, model 148, announced by the Allen du Mont Laboratories, 542 Valley Road, Upper Montclair, N. J. Includes a basically new sweep circuit having a range from 10 to 100,000 cycles per sec., with im-

CHALK ONE UP for the Designer



—He saved 25% on these Timer fastenings by specifying Self-tapping Screws

"Use bolts and nuts here . . . use machine screws in tapped holes there." It would have been easy for the designers of this Timer to write that hasty and conventional assembly specification after completing the electrical and mechanical features. However, assembly methods received careful instead of hasty consideration. And the result was a 25 percent saving on the fastenings!

Comparison showed that adoption of Parker-Kalon Type "Z" Hardened Self-tapping Screws instead of machine screws would eliminate the costly operation of tapping the brass parts. Also that these same unique Screws would save time and labor as compared with bolts and nuts for fastening contact springs to the Bakelite panel. Cheaper to use for both assemblies, the Type "Z" Self-tapping Screws made the assemblies stronger, too. *They always hold better under tension, shear and vibration than machine screws in tapped holes, or bolts and nuts.*

Many designers and production heads make it a practice to consider Self-tapping Screws whenever a fastening problem arises. While these Screws will not make every fastening cheaper and stronger, records do show that *in seven out of ten cases they provide a better job for less money.* So high an average of success makes it important for you to investigate the opportunities on your own jobs. Do it now. Send a brief description of one or more specific fastenings with the coupon. We'll furnish FREE samples of the correct type of Self-tapping Screw for a trial, with recommendations of our Assembly Engineers.

PARKER-KALON
HARDENED
Self-tapping Screws
PAT IN U.S. AND FOREIGN COUNTRIES

Where and How to use:-

Type "Z" Hardened Self-tapping Sheet Metal Screws

For joining and making fastenings to sheet metal up to six gauge; aluminum, die castings, Bakelite, etc. Simply turn Screw into drilled, pierced, molded hole. It forms a thread in the material as it is turned in. Can be removed and replaced.

Type "U" Hardened Metallic Drive Screws

This type of Self-tapping Screw is used for making permanent fastenings to iron, brass and aluminum castings, steel, Bakelite, Durez, etc. Hammer Screw into a drilled or molded hole. It forms a thread in material as it is driven.

Parker-Kalon Corp. 198 Varick Street, New York

Send samples of Self-tapping Screws suitable for fastenings described on attached sheet.

Name .....

Company .....

Address .....

Parker-Kalon Products are sold only through recognized distributors

proved linearity resulting from the use of a current limiting tube. The amplifiers associated with the tube can be arranged so that a signal of .2 volt gives a deflection of 1 inch. A Du Mont 54-H tube, having a calibrated scale on the fluorescent face, is used. Operates directly from 110 volts a.c. mains.

Cathode-Ray Oscillograph — Type HC-10-B1 Cathode-Ray Oscillograph and Time Axis Oscillator, suitable for operation from 50 or 60 cycle, 110 volts, a.c., is announced by the General Electric Co., Schenectady, N. Y. A 5 in. viewing screen is provided on the FP-53 Cathode-Ray Tube. Sensitivity is approximately 150 volts per inch for the front plate and 80 volts per inch for the back plate. The total wattage consumed by oscillograph and time-axis unit is 200 watts. Total weight is 97 lb. for the two units. The accelerating voltage is 3,000.

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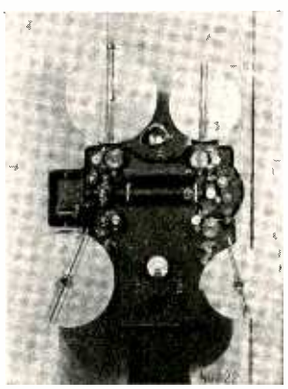
Miscellaneous Equipment

Sound Print Reduction Apparatus. An optical reduction printer system for producing high quality 16 mm. sound prints from standard sized negatives has been made available to printing laboratories by the RCA Manufactur-



ing Co., Photophone Division, Camden, N. J. The printer employs an optical system which reduces the sound track of the original in both transverse and longitudinal planes, thus reducing the sound track in correct proportions.

Control Unit. A control unit is announced by the Super Sensitive Controls Corp., 2970 Sheridan Road, Chicago, Ill., for universal applications

where positive and instantaneous control of electrical energy is required. Suggested uses are control of automatic heating plants, automatic refrigeration, scales or conveyors, fire and burglar alarm systems, door closers, and all types of photo electric cell operations.

Overload Relays. A series of light duty overload trip relays for direct or pulsating direct current is announced by the Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif. The relays are intended for use as safety devices

on various types of electronic apparatus for the protection of this equipment against excessive currents. Coils can be supplied to provide a trip action on from 25 milliamperes to 2 amperes d.c., with contact ratings of from 2 to 10 amperes. List prices are $4.50 to $6.00.

Auto Radio Power Analyzer. The Radiart Corp., Shaw Ave., at East 133rd St., Cleveland, Ohio, announces a radio power supply analyzer for auto radio installations, capable of testing all types of vibrators, transformers, condensers, and the like.

Dropping resistor. A line-voltage dropping resistor in a housing similar to that of the 5Z4 tube, containing resistance elements for use in series with heater type tubes and pilot lamps on 110 volt circuits. Provided with

octal base, and in 12 different ratings for different tube combinations. Current rating 0.3 amps for tubes, 0.250 amps for pilot lights. Manufactured by the Clarostat Manufacturing Company, Inc., 285 North 6th St., Brooklyn, N. Y.

Power Rectifier. The Ward Leonard Co., Mount Vernon, N. Y., announces the development of a rectifier for use with magnetic chucks. This device provides an economical means for obtaining rectified alternating current.

Literature

THE following manufacturers' bulletins, catalogs, and trade literature have recently been received:

✦ **Variable Air Condensers.** 1935-36 catalog of the Allen D. Cardwell Manufacturing Corp., 81 Prospect St., Brooklyn, N. Y., describing a complete line of receiving and transmitting condensers of the variable air-dielectric type.

✦ **Broadcast Station Equipment.** Catalog of broadcast equipment for broadcast stations and recording laboratory issued by the Gates Radio & Supply Co., of Quincy, Ill., including description of high fidelity apparatus, speech amplifiers, microphones, remote amplifiers, preamplifiers and transcription equipment.

✦ **Transmitting Tubes.** United Transmitting Tubes, a bulletin of United Electronics Co., 42 Spring St., Newark, N. J., together with information sheets on various types of power tubes used for A-F and R-F amplification, oscillation, etc.

✦ **Molded Products.** The October, 1935, issue of Durez Packaging News, published by General Plastics, Inc., North Tonawanda, N. Y., describing the applications of molded materials.

✦ **Relays.** Catalog No. 1-A of the Leach Relay Co., Los Angeles, Calif., describing relays for radio, telegraph, telephone, broadcast stations and general power purposes.

✦ **Mail Order Catalog.** Catalog No. 18 of Federated Purchaser, Inc., 25 Park Place, New York. Receivers and components, tubes, equipment used in radio and allied industries.

✦ **Component Parts.** Bulletin No. 250 of the National Co., 61 Sherman St., Malden, Mass., describing complete line of condensers, dials metal products, insulation and insulating forms, receivers, power supplies, etc.

✦ **Police Radio.** A bulletin of the National Electric Manufacturers Association, 155 E. 44th St., New York, entitled "Useful Information on Police Radio Systems," containing information for municipal authorities and others contemplating the purchase of this equipment.

✦ **Mail Order Catalog.** Catalog No. 59 of the Wholesale Radio Service Co., Inc., 100 Sixth Ave., New York, describing a wide selection of receivers, components, tubes, tools, etc.

✦ **Volume Controls.** 1936 Replacement Manual and Service Guide No. 2, issued by the Yaxley Manufacturing Division (P. R. Mallory & Co., Inc.), 3029 E. Washington St., Indianapolis, Ind.

Radioactivity by Bombardment

[*Continued from page 9*]

particle or a neutron, the other heavier particle constituting a nucleus which may or may not be one of the familiar stable elements. If it is not, then a radioactive element has been formed, as was first discovered[10] by Curie-Joliot in 1934. Such nuclei are unstable and some time later disintegrate spontaneously, emitting either an electron or a positron, and often a gamma ray of high energy. (The positron has the mass of an electron and the same quantity of charge, although of positive sign. It was first discovered[11] in studies of cosmic rays. Gamma rays are electromagnetic vibrations of the same type as light and X-rays, though of much shorter wave length.) The body that remains after the radioactive decay is almost always an ordinary stable element.

Every nucleus in a particular sample of radioactive matter does not burst at exactly the same instant, but the average time that elapses between its formation and its decay is highly characteristic of the element in question. The disintegrations are at first very numerous, but become less frequent as the supply of not-yet-disintegrated nuclei becomes exhausted. The time for half of the radioactive nuclei to have broken up is called the "half-life," and this varies, among the artificial radioelements, from a fraction of a second up to many months.

The radioactive strength of any material, measured by the number of electrons or positrons emitted per second, is obviously greater for short lived elements than for those of long life, if the same number of activated atoms is considered in each case, for the former class disintegrate at a more rapid rate. Further, some of the nuclei made radioactive during the early minutes of the activation bombardment decay before this process is finished; theoretically, with a given number of projectiles per second, an infinite duration of bombardment is necessary to reach the saturation state of maximum activity, when as many radioactive nuclei are being produced as decay every second. Actually, the net yield of active atoms increases with the time of bombardment in such a manner that an exposure equal to the half-life of decay produces one half the maximum activity, while in ten half-lives over ninety nine per cent of maximum is attained. It is therefore apparent that because of practical limitations of time much stronger samples of short lived elements can be produced than of long lived, assuming equal efficiency of transmutation per projectile.

Uses for the Radio-Elements

Both types of disintegration — those forming stable nuclei directly and those resulting in radioactivity —are equally of interest to the physicist, for much information on nuclear structure can be gained from studying the energies and numbers of the various particles that are formed and how these vary with the energy and type of projectile used. But the artificially produced radioactive elements are of perhaps wider general interest, since they offer great opportunity to the biologist and chemist. The latter is often desirous of knowing how fast a reaction takes place or how the constituents of a compound separate out under various conditions. If a small quantity of a radioactive isotope of the material in question be added, an extremely convenient and sensitive indicator is obtained, for the active substance reacts chemically just like the ordinary element and at the same time makes its presence known very definitely, through its effect on a simple electroscope. This procedure has already been used with naturally radioactive elements but only in those few cases where the material to be studied is chemically similar to the radioelement available. To have radioactive isotopes of all the elements will be obviously a great advantage.

Uses in Biology

On the biological side, a cheap and effective substitute for radium appears to be at hand, which may be of great value in the treatment of cancer. Instead of inserting into the tissue a small capsule of radium, or of its derivative radon, it may prove possible to inject directly into the tumor a salt solution containing, for example, radiosodium, made by bombarding ordinary salt with deuterons[12]. This emits gamma rays of approximately three million electron-volts energy, as well as electrons with energies ranging up to two million electron-volts. Best of all, the half-life of radiosodium is only 15.5 hours, so that no serious damage can be done to healthy tissues of the body by the gradual diffusion of the radioactive element into them; for in ten half-lives, or 155 hours, the activity is over ninety nine per cent gone. Also, the normal sodium atoms in the sample which were not activated during the bombardment can do no harm to the system, nor can the minute quantities of magnesium, into which radiosodium decays.

Within the past few years a great deal has been learned of nuclear structure and of the technique of producing transmutations at will. It is well within the realm of possibility that in the not distant future it will be possible to synthesize in quantity any desired chemical element, either stable or radioactive. A new science is being born, which, because of the fusion of subject matter, may equally well be called either nuclear chemistry or nuclear physics.

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[1]Rutherford, *Philosophical Magazine*, 37, 581 (1919)

[2]Since both the proton and the deuteron have a positive charge equal in magnitude to that of the electron, a new energy unit has come into use: the electron-volt, which equals the kinetic energy one electron or any similarly charged body acquires in falling freely through a potential difference of one volt. This amounts to 1.59×10^{-19} joule.

[3]Cockcroft and Walton, *Proc. Royal Soc.* A 136, 619 (1932)

[4]Crane, Lauritsen and Soltan, *Physical Review* 45, 507 (1934)

[5]Tuve, Hafstad and Dahl, *Physical Review* 48, 315 (1935)

[6]Van de Graaff, Compton and Van Atta, *Physical Review* 43, 149 (1933)

[7]Lawrence and Livingston, *Physical Review* 40, 19 (1932); 45, 608 (1934)

[8]Sloan, Thornton and Jenkins, *Review of Scientific Instruments*, 6, 75 (1935)

[9]Chadwick, *Proc. Royal Soc.* A 136, 692 (1932)

[10]Curie-Joliot, *Nature*, 133, 201 (1934)

[11]Anderson, *Physical Review*, 43, 491 (1933)

[12]Lawrence, *Physical Review*, 47, 17 (1935)

YOU CAN STRENGTHEN YOUR PRODUCTS WITH TEXTOLITE

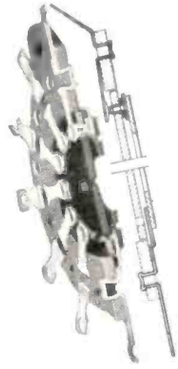
CHECK THE ADVANTAGES THIS LAMINATED MATERIAL PROVIDES

Textolite laminated is a strong material having high insulating qualities. It does not warp or shrink, and its insulating qualities are not affected by atmospheric conditions. No matter how delicate a device is, the inclusion of Textolite in its construction will give it strength, low ground leakage, and proper insulation of charged circuit parts.

✔ CHECK THESE SPECIFICATIONS *Point by Point* WITH YAXLEY SHORT WAVE SWITCHES

Specifications	*Yaxley Features*
1 Low, uniform and unchanging contact resistance.	"Silver to silver" contacts insure exceedingly long life and lowest possible contact resistance.
2 Imperviousness to atmospheric conditions.	moisture absorption.
3 Low capacity to ground	ground.
4 Elimination of coil absorption.	number of coil kept the coil in use.
5 Adaptability of all circuit arrangements.	Flexibility in coil and switch combinations for all circuit arrangements found in 1935 receivers.
6 Smooth operation with positive indexing action.	The finest quality of special metal springs and other metal contacts assure smooth mechanical performance
7 Proper shielding of circuits and coils.	minimize coupling.
8 Compactness of design	Switch can be mounted in a chassis base or between equipment where space is at a premium
9 Rugged construction to insure long life.	resistance

The shorting rotor plate of this switch section short circuits all the coils except the coil in use, thus eliminating coil absorption.



A Yaxley short wave switch section that has been cut in half with the cross-section drawing showing in heavy outline the heavy silver plating on all metal parts which assures lowest possible contact resistance.

Samples will be sent promptly upon receipt of a sketch or description of your requirements.

YAXLEY MANUFACTURING CO.
INCORPORATED
Division of P. R. Mallory & Co., Inc.
INDIANAPOLIS, IND.

MALLORY YAXLEY

For information as to the adaptability of Textolite to your needs, write Plastics Department, General Electric Company, West Lynn, Mass.

942-39

GENERAL ELECTRIC

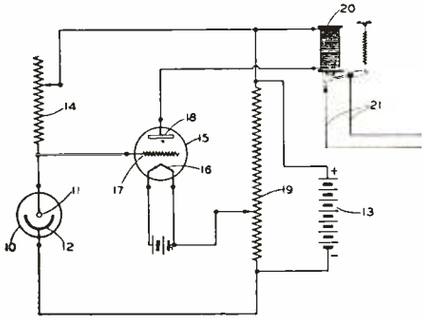
PATENTS REVIEW

PATENTS indicate trends. Next year's radio circuits, applications of electron tubes for non-communication purposes, new tube types, new materials, may be discovered by following United States and British inventions.

Electron Tube Applications

Illumination control. A photo-electric tube combined with a vacuum tube for control of artificial illumination. W. R. King, No. 2,012,821.

Control circuit. The combination of



a photo cell and voltage regulator tube. F. H. Shepard, RCA, No. 2,014,786.

Time interval measurement. A grid control rectifier circuit for receiving transmitted sound impulses and echo sounds. J. D. Tear, No. 2,012,837.

Machine tool. Vacuum tube apparatus for maintaining the motor at a constant speed under varying loads. 40 claims, Brown & Sharpe Mfg. Co., No. 2,011,068.

Rail flaw detector. Vacuum tube method response to flux variation surrounding the rail. E. G. Sperry, Sperry Products, No. 2,011,425.

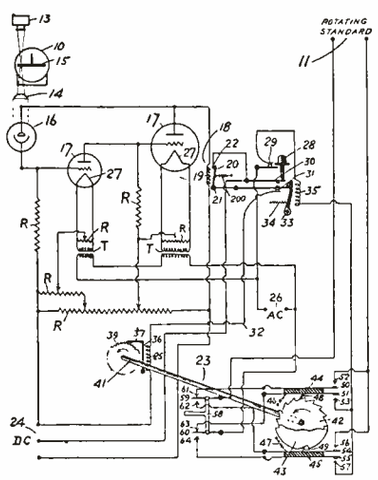
Temperature measurement. A high frequency oscillator with a condenser whose capacity varies with a variation in temperature. A. H. Davis, National Aniline & Chemical Co., Inc., No. 2,011,710.

Conductivity measurement. An eletron tube for ascertaining the conductivity of materials which are polarized upon passage of d-c current. Albert Preisman, New York, N. Y., Nos. 2,010,242; 2,010,243.

Time indicator. Means for indicating lengths of energized and de-energized periods on a welding system. H. W. Lord, G.E. Co., No. 2,011,366.

Translating apparatus. No. 2,013,390 a Polyphase X-Ray System, W. X-Ray Co. No. 2,013,454, an electric power transmission, C. H. Willis, G.E. Co. No. 2,013,221, C. Stansbury, Cutler-Hammer, motor controller. No. 2,010,-577, B. J. Wilson, Leeds & Northrup Co., motor control system. No. 2,008,-855, W. E. Co., regulating system for dynamo-electric machines. No. 2,010,-697, H. W. Lord, G.E. Co., a peak voltage measuring device. No. 2,011,381, C. G. Suits, G.E. Co., an electrical system providing sequence of operation. No. 2,012,426, to F. H. Gulliksen, W. E. & M. Co., regulating apparatus. No. 2,012,573, T. H. Long, W. E. & M. Co., translating apparatus. No. 2,012,588, F. G. Logan, Ward Leonard Electric Co., electric regulating apparatus. No. 2,012,884, Louis Leroy, Paris, France, a circuit for regulating vapor electric discharge rectifier tubes. No. 2,015,591, E. D. Cook, G.E. Co., on a control circuit. No. 2,013,815, Roy J. Wensley, W. E. & M. Co., protective apparatus for a-c circuit. No. 2,011,-970, J. W. Dawson, W. E. & M. Co., heat transfer apparatus control. No. 2,016,-148, H. B. LaRoque and F. R. Elder, G.E. Co., on a power control system. No. 2,016,147, C. W. LaPierre, M. S. Mead and F. B. Menger, G.E. Co., on electric tripping circuit.

Meter testing. Method of comparing a meter to a rotary standard by means

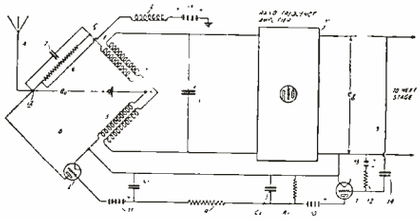


of a photocell and amplifier circuit. Frederick Strattner, Manoa, Pa., No. 2,013,393.

Color matching. Radiation is projected on the article to be matched. Photocell having a response that varies in accordance with the variation of the wave length of the radiation, but is constant for variations in total radiant flux impinging thereon and emitted by the article to be tested. E. D. Wilson, Wilkinsburg, Pa. W. E. & M. Co., No. 2,008,410.

Amplification, Detection, etc.

Automatic volume control. A bridge normally unbalanced between the source and the amplifier input with a signal rectifier connected between an arm of the bridge and the output of the amplifier for controlling the bridge balance to automatically adjust the



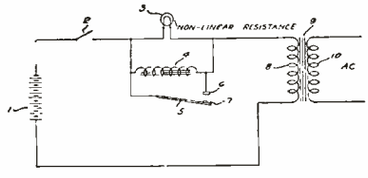
transfer of energy from the source to the amplifier. Stuart Ballantine, RCA. No. 2,014,831. See also No. 2,016,366, P. O. Farnham, RCA.

Modulating system. A double button carbon microphone connected to a source of energy higher than the audible range, a full wave rectifier and connected to an oscillator. A. K. Ward and P. M. Craig, RCA. No. 2,015,827.

Acoustic devices. Several patents. Nos. 2,007,746 to 2,007,750 to R. W. Carlisle, Abraham S. Ringel, H. F. Olson and L. J. Anderson, RCA, on high-fidelity loud speakers in which the voice coil has two windings, etc.

Testing oscillator. A radio testing instrument providing several harmonic frequencies for determining the operating condition of a radio receiver. Floyd Fausett, Supreme Instruments Corp. No. 2,016,084.

Converter. Device for converting d.c. to a.c., including a non-linear resistance and means for shunting the



resistance at intervals. W. F. Cotter and M. E. Bond, United American Bosch Corp. No. 2,013,878.

Push-pull circuit. Method of operating the grids at a positive potential in the absence of signal waves in the input circuit. Charles Travis, RCA. No. 2,016,402.

Logarithmic amplifier. A circuit in which the grids of several tubes are connected through a condenser respectively in parallel across the input with the object of getting a total resultant characteristic which varies substantially logarithmically. H. O. Roosen-

stein and Wilhelm Runge, Telefunken. No. 2,014,509.

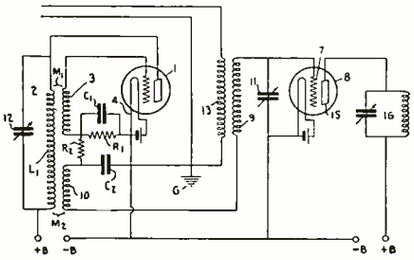
Frequency control system. A long line oscillator and circuit. J. W. Conklin, RCA. No. 2,014,424.

Negative feedback system. Circuit which tends to sing at a frequency outside of the utilized frequency range. This tendency is reduced while keeping unchanged the loop gain at a given frequency in the utilized frequency range. H. S. Black, B. T. L., Inc. No. 2,011,566.

Magnetostrictive circuit. A frequency-discriminating sound transmitter using magnetostriction. No. 2,014,412 to G. W. Pierce, Cambridge, Mass., and No. 2,014,413 on a system for the reception of frequencies higher than speech frequencies.

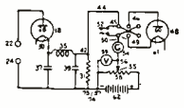
Program distribution. Two patents to A. R. Hopkins, RCA, on radio frequency distribution system for trains. No. 2,008,279 and 2,008,280.

Constant output oscillator. Method of supplying automatic bias to a frequency changer in a superheterodyne, by connecting the grid and cathode of the first detector tube respectively to the negative and positive ends of a resistance to produce a negative bias



on the control electrode of the first detector varying directly with the voltage of the oscillator whereby the optimum value of negative bias is automatically produced for each frequency of oscillation. No. 2,017,019 to S. W. Seeley, RCA. See also No. 2,017,020 on a negative bias system for audio frequency amplifiers to S. W. Seeley.

Modulation meter. The waves are rectified, the average values and the deviations of the maximum and mini-

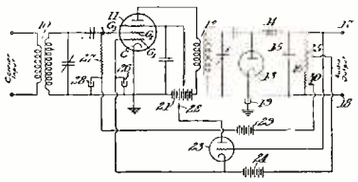


mum values from the average value are measured. W. N. Tuttle, General Radio Co. 22 claims. No. 2,012,291.

Push-pull amplifier. Means for negatively biasing the control-grids under control of the d-c component of the anode currents of the tube. The first tube is normally under-biased and the second tube is normally over-biased. E. F. Carter, Hygrade Sylvania Corp. No. 2,014,520.

Automatic volume control. H. A. Wheeler, Hazeltine Corp. Filed April 6, 1932. 23 claims. No. 2,013,121.

Volume control. Use of tubes having several grids; means for establishing different d-c potentials upon the several grids, controlling the amplification by simultaneously adjusting the d-c potentials upon at least two of the grids in accordance with the strength



of signals applied to the amplifier. K. C. Black, RCA. Application April 14, 1930. 37 claims. No. 2,013,297.

Preselector system. By means of negative resistance the resonance characteristics of an antenna, for example, is sharpened. W. F. Curtis, Beaver Heights, Md. No. 2,013,650.

Selective a.v.c. Method of quieting receiver when energy transmitted from the input decreases below a predetermined level. W. A. Harris, RCA. No. 2,013,307. See also No. 2,010,252 to L. E. Barton, RCA, on the same subject.

Band pass tuner. A preselector system. A. T. Witts, RCA. No. 2,012,030.

Multi-range receiver. Including means of regeneration. P. J. Snider, RCA. No. 2,011,941.

Variable band receiver. Interstage coupling comprising an essential and an auxiliary circuit with the coupling between the latter two circuits adjustable so that the sensitivity of each stage is automatically reduced when the selectivity is decreased. W. v B. Roberts, RCA. Re-issue. No. 19,668.

Program selector. A timed radio program selector. G. G. Pernod, New York, N. Y. No. 2,010,826.

Automatic tone control. A connection between a tone control circuit and a radio frequency amplifier whereby the transmission of currents of higher audio frequency is varied in the same direction as the change in amplification of the amplifier. Rudolf Rechnitzer, Telefunken. No. 2,012,321.

Multi-band receiver. Switching system involving feedback. R. M. Planck, RCA. No. 2,015,191.

Control system. A time control switch element for automatically tuning the receiver at given intervals. E. E. Temple, Denver, Colo. No. 2,010,044.

Control circuit. Means for simultaneously actuating sensitivity, selectivity, fidelity control. G. L. Beers, RCA. 32 claims. No. 2,010,131.

Remote tuning. Method of remote control and automatic tuning. H. B. Fuchs, Brooklyn, N. Y. No. 2,012,603.

Patent Suits

1,313,094, I. Langmuir, System for amplifying variable currents; 1,729,-048, F. G. Myers, Method of making talking motion pictures; 1,756,863, C. A. Hoxie, Method of making motion picture films; 1,840,351, W. L. Douden, Sound record and method of producing same; 1,854,159, L. T. Robinson, Sound recording, filed Apr. 20, 1935, D. C., S. D. Calif. (Los Angeles), Doc. E 650-M, *R C.A et al.* v. *R. M. Like et al.*

1,403,475, H. D. Arnold, Vacuum tube circuit; 1,403,932, R. H. Wilson, Electron discharge device; 1,811,095, H. J. Round, Thermionic amplifier and detector; 1,936,162, R. A. Heising, Transmission system; 1,702,833, W. S. Lemmon, Electrical condenser, D. C., S. D. N. Y., Doc. E 80/142, *R.C.A. et al.* v. *Lenox Engineering Co., Inc., et al.* Consent decree for plaintiff (notice May 31, 1935).

703,929, F. E. Ives, Photochromoscopic and trichromatic apparatus; 1,253,796, L. F. Douglass, Camera; 1,416,645, C. F. Jones, Duplex camera, filed May 1, 1935, D. C., S. D. Calif. (Los Angeles), Doc. E 658-J, *Technicolor Motion Picture Corp.* v. *L. F. Douglass et al.*

1,455,141, Lowell & Dunmore, Radio receiving apparatus; 1,606,212, same, Power amplifier; 1,635,117, F. W. Dunmore, Signal receiving system, C. C. A., 4th Cir., Doc. 3816, *P. D. Lowell et al.* v. *A. G. Triplett et al.* Decree reversed June 4, 1935.

Re. 18,579, Ballantine & Hull, Demodulator and method of demodulation; 1,297,188, I. Langmuir, System for amplifying variable currents; 1,573,374, P. A. Chamberlain, Radio condenser; 1,618,017, F. Lowenstein, Wireless telegraph apparatus; 1,707,-617, 1,795,214, E. W. Kellogg, Sound reproducing apparatus; 1,894,197, Rice & Kellogg, same, D. C., S. D. N. Y., Doc. E 80/143, *R.C A. et al* v. *Lenox Engineering Co., Inc., et al.* Consent decree for plaintiff (notice May 31, 1935).

1,828,094, H. Andrews, Electrical frequency changing apparatus of the thermionic type, D. C. Dela., Doc. E 1046, *Radio Patents Corp.* v. *Westinghouse Electric Supply Co.* Consent decree dismissing bill without prejudice April 3, 1935.

1,297,188, I. Langmuir, System for amplifying variable currents; 1,573,-374, P. A. Chamberlain, Radio condenser; 1,728,879, Rice & Kellogg, Amplifying system, D. C., S. D. Calif., C. Div., Doc. E 551-H, *R.C.A. et al.* v. *J. L. Misrach (United Radio Stores).* Patents held valid and infringed (notice July 25, 1935).

1,879,863, H. A. Wheeler, Volume control, C. C. A., 2d Cir., Doc. —, *Hazeltine Corp.* v. *B. A. Emerson Television Radio, Inc., et al.* Decree affirmed (notice July 31, 1935).

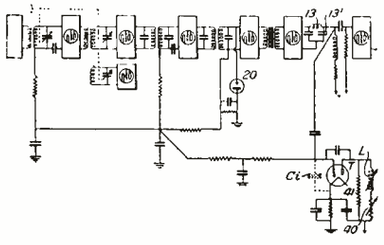
British Patents

Radio Circuits

Testing circuit. A single-tube oscillator, primarily intended for testing, demonstrating, or servicing wireless receivers comprises a screen grid tetrode, connected as a dynatron by biassing its screen grid to a higher positive potential than the anode. W. F. Brown, Staffordshire. No. 423,961.

Superheterodyne. An amplifier and a dynatron oscillator feed a rectifier in whose output circuit is a resistance. The output signal is taken from this resistance. The rectifier also has a resistance in the anode circuit and the voltage across this is applied to the grid of an oscillator. The control rectifier is bias delayed to be inoperative until the signal exceeds the voltage applied to the anode of the oscillator and cathode of the rectifier. The object is to improve the discrimination against interference. RFL, Inc. No. 424,197.

Automatic tone control. A capacity for use as a tone control is variable in accordance with an applied voltage and comprises a tube having a condenser between the plate and grid and an impedance in the anode circuit. The effective input capacity of the tube under these conditions is a function of the grid-plate capacity, the mutual



conductance and the load impedance and can thus be adjusted by varying the grid voltage. The circuit shows the application to the over-attenuation of higher frequencies, therefore the reduction of noise when a weak station is being received in a superheterodyne, in which a voltage for a.v.c. is derived from a diode. J. Yolles, Marconi Co., No. 428,772.

Detector reception. In a diode detector the anode is connected to a more positive point on the load circuit than the cathode to avoid distortion with high percentage modulation. C. Travis, Marconi Co., No. 427,018.

Superheterodyne. A detuned oscillator is used to produce a control wave which prevents reproduction of the signal when the receiver is out of tune by a predetermined amount. E. K. Cole, No. 431,006.

Tuning aid. To permit accurate aural tuning, a receiver in addition to having an a.v.c. is a means for decreasing the sensitivity on departure of the tuning of the receiver from resonance with the received signal by making the selectivity of the a.v.c. potentials to be less than those used for producing aural tuning control. Associated Electrical Industries, No. 429,429. See also No. 429 428, on automatic volume control circuits.

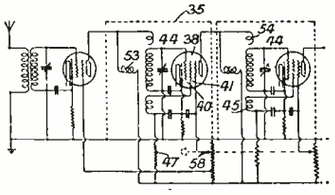
Tuning systems. In a receiver tuned by ganged variable inductance of the moving core type, the tuning range is altered by varying the capacity of the tuned circuits by switching-in fixed condensers. Johnson Laboratories, W. J. Polydoroff, No. 429,471.

Superheterodyne. The frequency-changing stage is so arranged that the same variable condenser serves to tune the receiver to the incoming signal and to tune the local oscillator. Hazeltine Corp., No. 425,659.

Local oscillator circuit. The grid of the oscillator is connected to an intermediate point on a grid leak resistance, a condenser being across the upper part of the grid, having such a value that the phase angle of the impedance between the grid and the high potential end of this resistance corresponds to that of the impedance between the grid and the cathode. By this means, the effect of variation in grid-cathode capacity of the oscillator tube to improve replacement on the oscillator frequency is minimized. Philips, No. 425,880.

Remote control. A transmitter or receiver having a low impedance circuit for transferring high-frequency signal circuits from the control apparatus to the transmitter or receiver. Plessey Co., No. 426,011.

R-f amplifier. In an r-f pentode circuit the coupling between stages is partly magnetic and partly capacita-



tive, with regeneration available to obtain equal overall amplification over the tuning range. A. V. Loughren, No. 426,109, Marconi Co.

Automatic volume control. A controlled direct current is used to vary the saturation of the ferro-magnetic core of an inductance. Marconi Co., No. 426,347.

Frequency multiplier. The frequency separation between desired and undesired signals in a radio receiver is increased by using the first stage as a frequency multiplier comprising two tubes with push-pull input, biased to the lower bend. Their output circuits are in parallel to balance out the fundamental frequency. A. C. Cossor, No. 426,350.

Frequency Modulation. Two patents to E. H. Armstrong. No. 426,227 relates to a method of producing frequency or phase modulated signals. No. 426,228 relates to a system for increasing the signal strength with respect to hiss. A wide band is used with current limiters, a pair of balanced detectors which respond cumulatively to frequency modulated signals and differentially to amplitude modu-

FIG. 2.

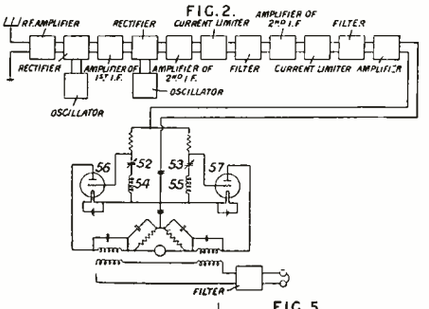
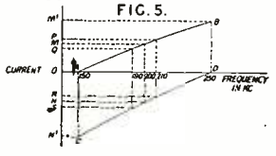


FIG. 5.



lated variations. Assuming an unmodulated 200 kc. carrier, audible tube hiss arising from filament variations is limited to the range from 190 to 210 kc. By the circuits 52, 54, 53, and 55 this noise effect is wiped out. It is stated that on 6 meters, the tube noise is reduced to 1 per cent of its normal value.

Noise suppressor circuit. Method for reducing the amplification preceding the detector when the received signal strength is below a predetermined level. Marconi Co., No. 426,893.

Superheterodyne. Complete separation of the original frequencies from the combination frequencies resulting from frequency conversion in a superheterodyne is achieved by the use of two control grids separated by a screen grid. G.E. Co., No. 426,512.

A.v.c. circuit. A varying master-bias voltage is arranged to vary the bias of each controlled tube only between definite limits both determinable for each tube. Murphy Radio, No. 426,803.

Frequency converter. A modulation system comprising a tube having two grids separated by a positively biased screen electrode, modulating potentials being applied to one grid and r-f oscillation to the other, the output circuit being between anode and cathode. Hazeltine Corp., No. 426,855.

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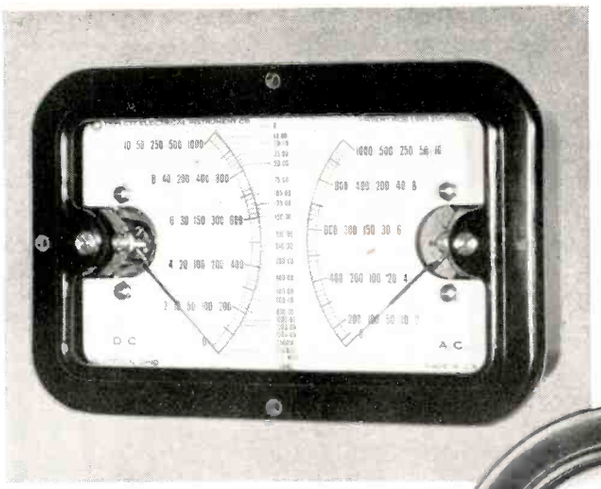

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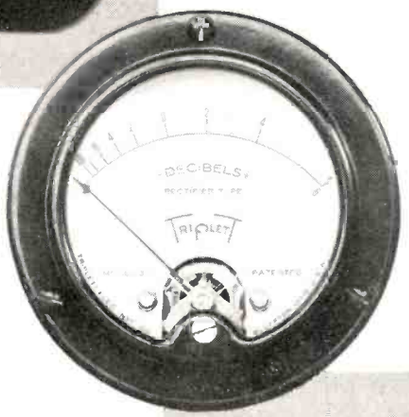

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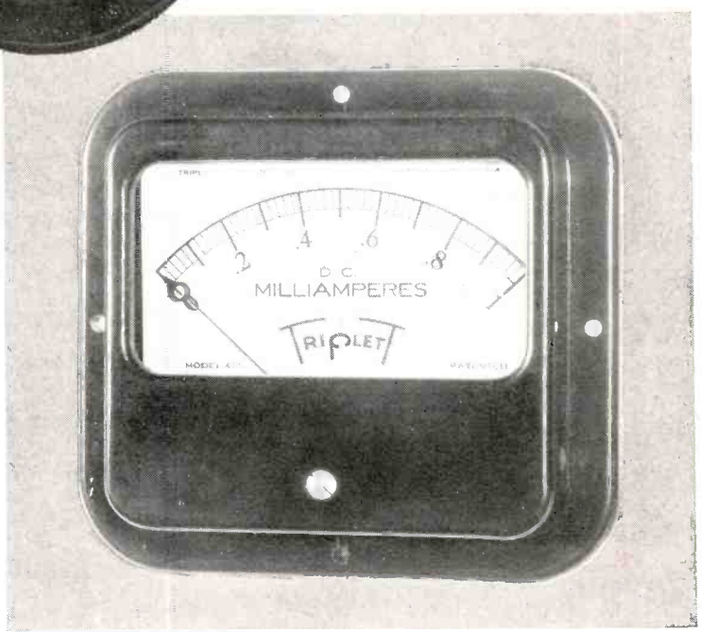

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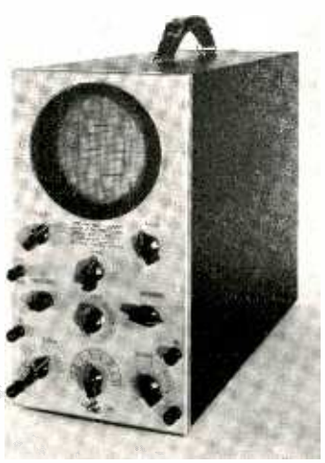

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Of Electronics, published monthly at New York, N. Y., for Oct. 1, 1935.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared D. C. McGraw, who, having been duly sworn according to law, deposes and says that he is the Secretary of the McGraw-Hill Publishing Company, Inc., publishers of Electronics, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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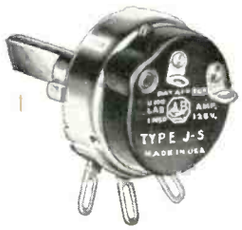
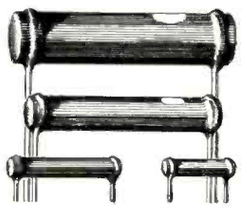
● After molding, the unit cannot change; even severe service cannot alter its performance. Long wear does not deteriorate this unusual Allen-Bradley resistor. Even high humidity has no effect on Bradleyometer Types J and JS; they remain permanently quiet.



Type JS Bradleyometer

● These volume controls are only 1 1/16 in. in diameter. They are available with or without a built-in line switch actuated by the control knob. They are interchangeable with other units built to R. M. A. standards.

Allen-Bradley Co.
110 W. Greenfield Ave., Milwaukee, Wis.

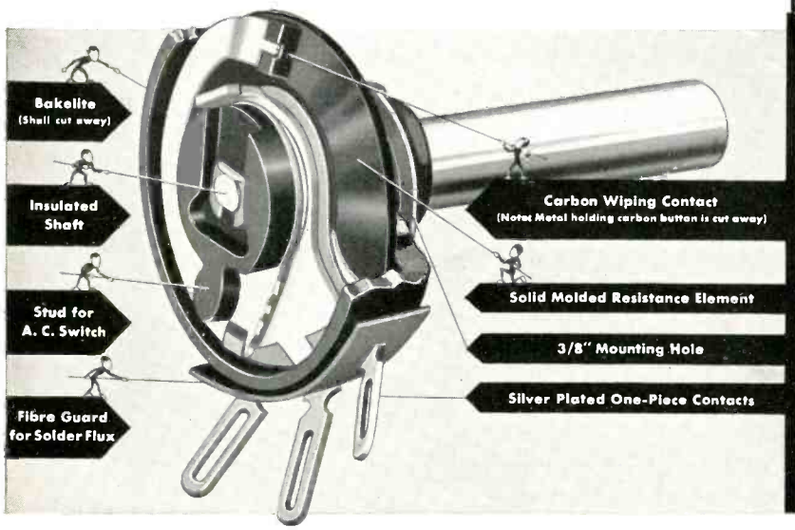


SPECIFY BRADLEYUNITS IF YOU WANT QUIET, DEPENDABLE RESISTORS

These solid molded fixed resistors have an exceptionally low voltage coefficient. Moisture and age do not affect them. All manufacturing processes are under continuous laboratory control. Such uniformity of manufacture assures resistors that are quiet and dependable in radio receivers.

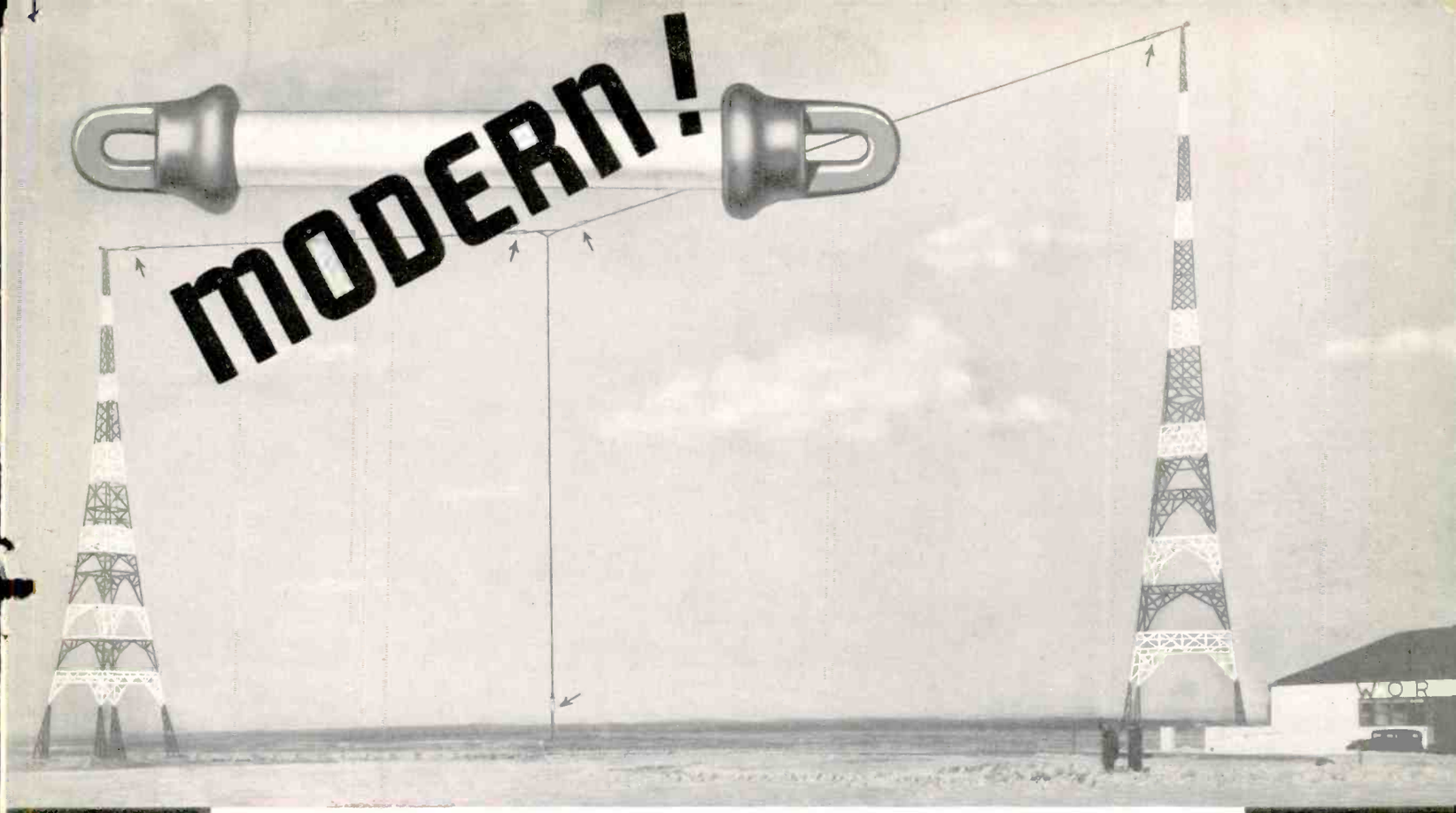
SUPPRESSORS THAT HAVE NO HIGH VOLTAGE CHARACTERISTICS

Allen-Bradley Suppressors do not "open circuit" in service; they do not "drop" in resistance and, therefore, fail as suppressors; they do not have a high voltage characteristic; they do not fail from exposure to oil and water; they do not break due to car or engine vibration. These resistors are enclosed in rugged, non-arcing bakelite casings.



ALLEN-BRADLEY RADIO RESISTORS

the Choice of the World's Largest Radio Manufacturers



Panorama of WOR 50 K.W. Broadcast Station

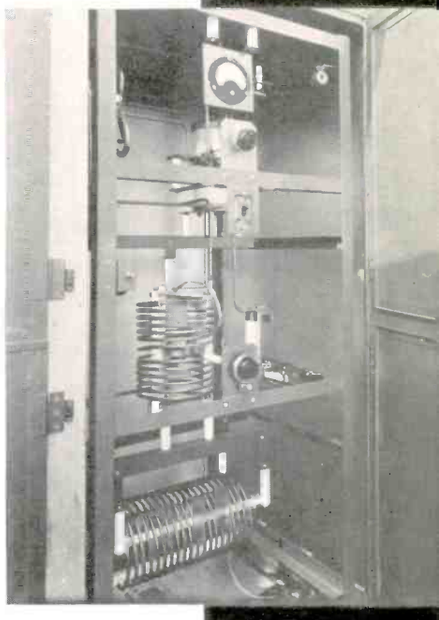
ISOLANTITE PLAYS AN IMPORTANT ROLE IN THE MODERN BROADCAST TRANSMITTER.

The 50 K.W. Transmitter recently built by Western Electric for Station WOR employs ISOLANTITE liberally.

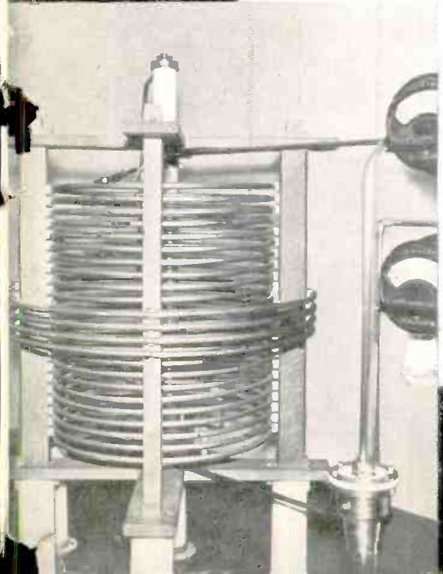
In this up-to-date station are strain insulators, concentric transmission line spacers and end seals, stand-offs, switches, shafts, inductance supports, power and rectifier tube supports, condenser cases, pedestals and many other parts of ISOLANTITE.

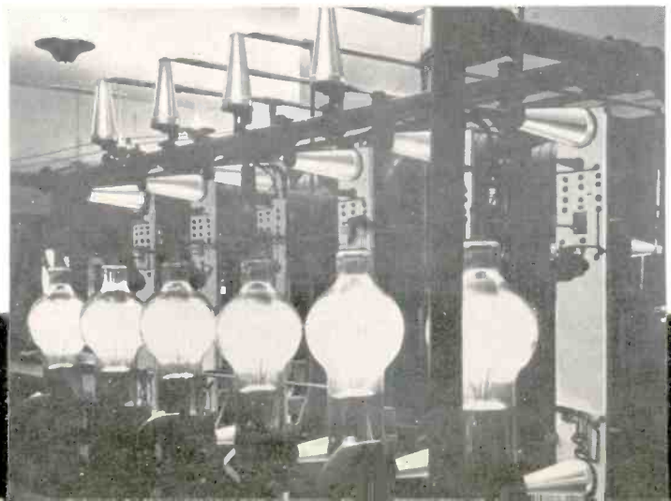
To improve your equipment, specify ISOLANTITE insulation. *Isolantite Inc., 233 Broadway, New York, N. Y. Factory at Belleville, N. J.*

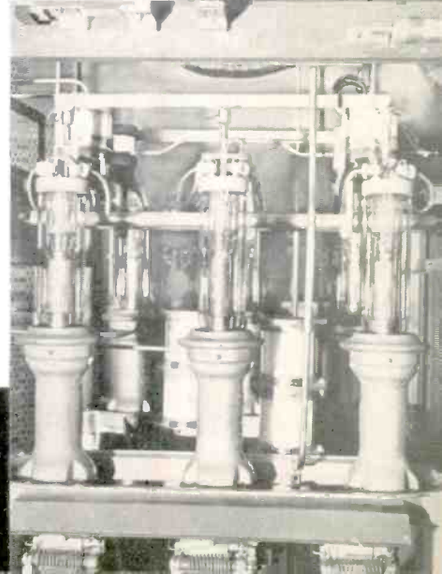
Represented by GRAYBAR ELECTRIC CO.



Isolantite
CERAMIC INSULATORS







A Clear Path Ahead
with RCA ALL-METAL TUBES

COMPROMISES are always irksome; in fundamental radio design they impose a serious handicap that can never really be overcome, no matter how perfectly the design limitations are compensated for by refinements in execution.

Highly perfected though glass tubes are, they involve a basic compromise: they are manufactured in accordance with a technique borrowed from a fundamentally unrelated industry.

RCA All-Metal Tubes abolish that compromise. They are designed and built as radio tubes should be, from the ground up. In one stroke they sweep away countless obstacles that beset the equipment designer's path. The road ahead is clear.

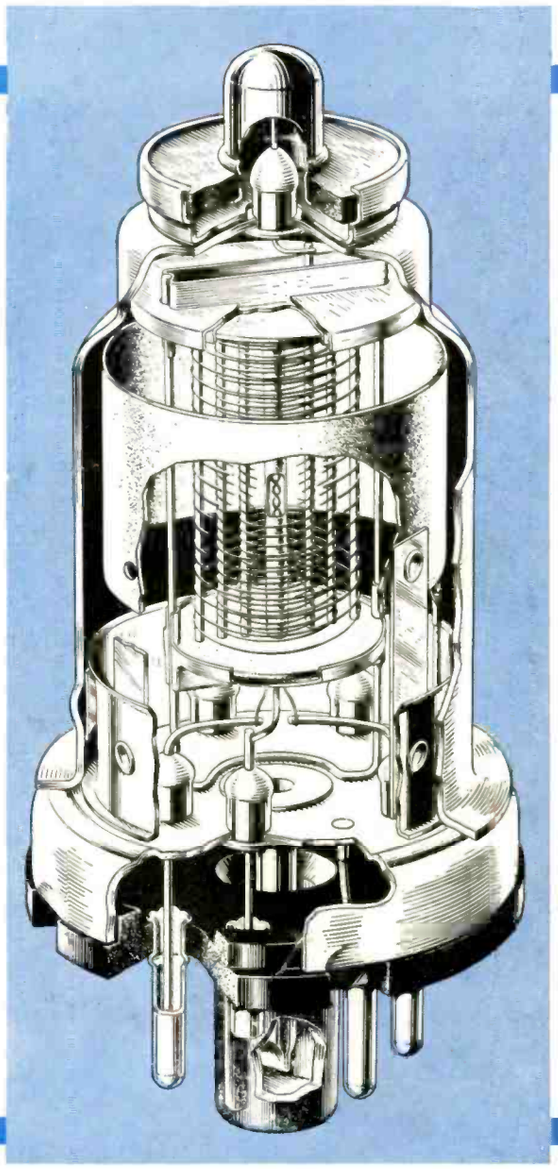
With metal, tolerances can be closer. With metal, more and more automatic machinery can be used, resulting in finer accuracy, greater uniformity and progressively lower production costs. With metal, shielding is very nearly perfect. With metal, no charge accumulates on the shell.

With metal, leads are shorter, are more direct, and contribute to rugged support of the elements. With metal, tubes are more compact and, therefore, make possible more efficient chassis designs.

With metal comes the opportunity to standardize on a few fundamental types to take the place of several score of glass types, many of which overlap in function.

Available in metal is the new pentagrid mixer—the 6L7—the advantages of which equipment designers have been quick to recognize.

These are some of the features of RCA All-Metal Tubes, as designed by General Electric and made by RCA. Because of the features of metal tubes—no less than the potent sales appeal of their very *newness*—48 set manufacturers have adopted all-metal tubes.



RCA

RCA RADIO TUBES

RCA Manufacturing Co., Inc., Camden, N. J.; a subsidiary of the

RADIO CORPORATION OF AMERICA